COMPRESSED AIR

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATIONS OF COMPRESSED AIR

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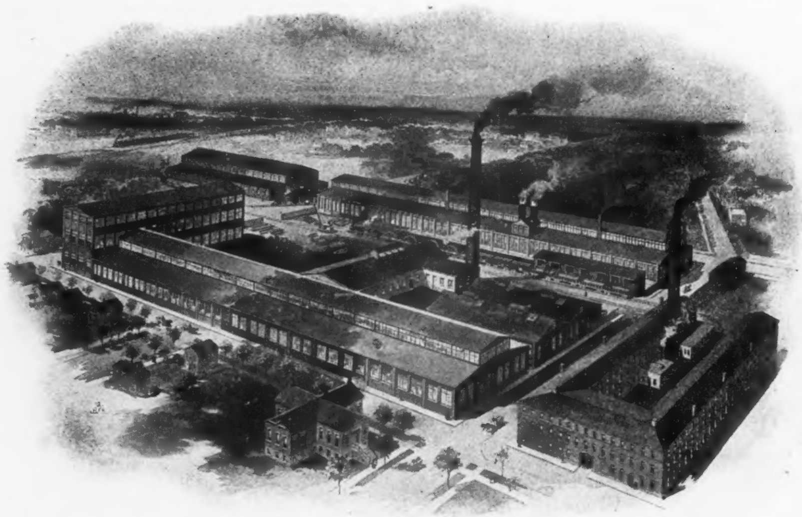

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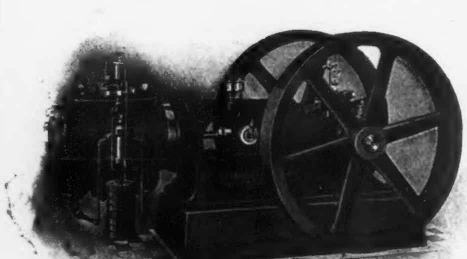

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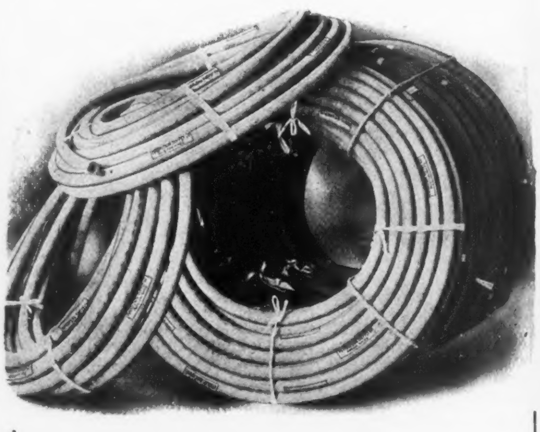

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COMPRESSED AIR

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A monthly magazine devoted to the useful applications of compressed air.

SEPTEMBER, 1907.

A MONTH'S OUTPUT OF AIR COMPRESSORS

By Frank Richards.

Compressed air in the last twenty years, and especially in the last decade, has had its work extended far beyond its original field of employment. The business of manufacturing air compressors was begun almost upon compulsion to supply the needs of the rock drill in mine and tunnel work. The readiness with which air compressors have become procurable, the persistent aim of the manufacturers to adapt the machines to the varied requirements of different lines of service as they have developed, the attention which has been given to the promotion of the possible economies in the development of power and in its application to this specific purpose, the perfect reliability and automatism which have become so characteristic of the best makes, have made their services highly desirable in many, if not most, lines of industry, and accordingly to-day the rock drill is only one of many large and constant users of compressed air, and the air compressor finds employment in connection with every line of human activity.

While the rock drill was thus the first employer of the air compressor, the latter has now fully reciprocated the service, and by its ready and almost universal presence has made more and more work for the rock drill and its lineal descendants. The rock drill has developed into the pneumatic tool, and this has multiplied and differentiated until the relationship of some of the successors to the original percussion drill can no longer be traced, and the work they do is as far as possible from the drilling of rock.

I have before me a detailed list of the output of air compressors by the Ingersoll-Rand Company for a recent calendar month; that is, from the 16th of one month to the 15th of the next, inclusive, and from it we may gather a number of items as to the extent and diversity of the employment of compressed air at the present time. This is not an altogether typical month's business, as several types of compressors which are generally represented in a month's list of sales by this company do not figure in this, and the shipments also have not the usual reach of the foreign trade. Whether the total for the month is larger or smaller than the average I do not know; I merely have happened to catch on to this particular list and have got what I could out of it.

The number of compressors in the list is 173 and the aggregate horse-power is 16,000, making 92 the average horse-power for the entire list, so that these are not little machines which would be of no account except for the number of them.

The total free air per minute capacity of these machines is 97,000 cubic feet, this volume being equal to that of a cube with a side of 46 feet. Nothing can be deduced from this as to the economy of power in compression, as the air is delivered at various pressures, the compressors also working at different altitudes and under various other conditions affecting the ultimate economy.

If any one is disposed to think that the building of air compressors is a simple business, comparable, for instance, with the building of steam engines, attention is called to the fact that there are 85 different types, styles, sizes or combinations of details included in this list of 173 machines. Taking the list all through the average is only about two machines which duplicate. The month preceding or the month following would each show a number of still different machines, and so on throughout the year, and the number of different machines which may be called for is almost endless. It is, in fact, actually endless, for new machines are coming along continually, each having some honest claim for preference over previous designs, and new requirements arise calling for other new arrangements.

The great variety of the machines represented in the list is not due largely either to caprice or to complete error of judgment. There is a reason, not always of sufficient weight to be authoritatively conclusive, but still a definite and tangible reason, to be advanced for each selection. For instance, if we divide the list as below the reasons or the prevailing considerations will begin to appear.

STEAM-DRIVEN.

Single steam and single air cylinders	53
Single steam and compound air cylinders	4
Duplex steam and duplex air cylinders	5
Duplex steam and compound air cylinders	17
Compound steam and comp'd air cylinders	18
POWER-DRIVEN.	
Electric drive and single air cylinders	3
Electric drive and duplex air cylinders	13
Belt or gear and single air cylinders	24
Belt or gear and duplex air cylinders	12
Belt or gear and compound air cylinders	4
Belt or gear and three-stage air cylinders	20
	173

The reason, or, rather, the explanation, for the first and largest item of this list, that of the 53 compressors with single steam and single air cylinders, 54 per cent. of all the steam driven machines, is perhaps the least defensible of all. These machines represent to a certain extent the survival of the unfittest. The earlier air compressors were first of all cheap and simple; they ignored almost completely the evidently possible economies of operation. Both in the use of the steam for the development of the power and in its application to the work of compression they were wasteful almost to the limit of the possibilities in that direction, and their wide employment retroacted to the discrediting of compressed air for all purposes. Great numbers of these compressors survive in active service, and, except for the wasting of the fuel, they give such satisfaction and entail so little other expense in supervision and maintenance that many who are accustomed to them will have no others. There are many compressors in this lot to which these remarks only partially apply, they being machines of small size and therefore more or less justified in ignoring the possible economies which in their case would be too minute for practical consideration.

The next largest number in the list of steam-driven machines, the 18 with compound steam and compound air cylinders, these being about 18½ per cent. as compared with the 54 per cent. above of the total of steam-driven compressors, represent the machines which realize the highest practicable economies in operation. It is understood that condensers for the steam and intercoolers for the air are employed, and then it is a common thing for compressors of this class to show a saving of one-half of the fuel used as compared with the consumption of the class first mentioned, so that when in continuous operation they may be said to pay for themselves in a short time, some of them, as the records will show, in a single year.

It must not be assumed that the entire economies of this class are available for all steam-driven compressors, or that all compressors should be built with both compound steam and compound air cylinders, although the number of these should be largely increased. It is a rather curious thing that in the month's list of compressors here under consideration there is not a single example of the class of compressors, built by the same company, most numerously employed in connection with the New York subaqueous tunnel work. These would appear in the list as "compound steam and duplex air," the two air cylinders of each machine being both for single-stage compression, and for the very sufficient reason that the air pressure required does not usually exceed 30 pounds.

Next in numbers on the list are the seventeen "duplex steam and compound air." The four "single steam and compound air" really are the same as to economy of operation, the former machines being double and the latter single. Many compressors are so small as to make the compounding of the steam end hardly worth while, and for that reason we may excuse the four single machines, but we may infer that the duplex machines were large enough to make the compounding of the steam ends, with of course condensers and if possible high-pressure steam, the only proper thing, but customers and users are not yet all educated up to this.

The proportion of power-driven machines, as distinguished from direct-steam machines, continually increases, and for this the electric drive is a sufficient explanation. We may assume that more than one-half of the belt or gear driven machines in the list are really motor driven, in addition to those listed as "electric," the latter having the motor provided as an integral part of the machine.

The twenty three-stage machines in the power list represent the highest possible economy as to the compression of the air impressed for special service; the other power-driven machines generally represent the smaller compressors of the list, but still it does not look well to see only four compound air ends in the lot. It does not represent the approved and strenuously advocated practice of the builders, but rather the peculiar over-

weighing of first cost by the purchasers. They may save a little in the machinery bill but must pay it out elsewhere and without end.

Running down the list and noting the purchasers, a rather astonishing variety of industries is indicated in these sales of a single month. No attempt is made at arrangement: Talc company, stone quarry, building contractor, car works, ice company, plate-glass company, coke company, railroad companies, coal mines, boiler works, foundries, stone yards, carbide company, prospecting, iron mines, structural iron works, machine tool works, motor car works, city corporation, fuel company, sand company, carpet cleaning, rapid transit company, gas engine works, dredging company, kodak company, meat packing company, lumber company, steel foundry, malleable iron foundry, scale works, oil company, dye works, salt company, rubber company, sheet and tube works, lead and smelting company, gaslight company, shipbuilding company, water works, pneumatic dispatch, technical school, brewing company, wrecking company, silk mill, electric light company, glue works, pump works, cement works, water company, park company, cold storage, distillery.

In the lines of quarrying and mining and also in railroading, which would include both the driving of tunnels and shop and yard work, there are of course several entries, and more than one under most of the others mentioned, while many give no indication of the line of business, but the variety of employment would seem to be sufficiently indicated.

These compressors will be distributed over thirty of the States of the Union, as follows: New York, 39; Pennsylvania, 37; Ohio, 12; New Jersey, 9; Massachusetts, 8; Illinois, 5; Maryland, 4; Virginia, 4; Alabama, 3; Georgia, 3; Indiana, 3; Michigan, 3; Montana, 3; Tennessee, 3; Florida, 2; Kansas, 2; Kentucky, 2; Minnesota, 2; North Carolina, 2; New Mexico, 2, and Arizona, Arkansas, Idaho, Iowa, Rhode Island, Texas, Utah and Vermont, 1 each. The foreign business of the company, usually reaching at least half a dozen countries per month, is in this list represented only by four compressors to Mexico. The number of compressors here credited to New York is misleading, many having been sold in New York City to the resident representatives of companies doing business in distant States. Pennsylvania is undoubtedly by far the bigger customer.

All lines of business in all parts of America and in all foreign lands are thus interested in and more or less dependent upon the air compressor, and the demand for its constant services was never more active and growing than to-day. The growth is much more rapid than that of population, the per capita "consumption" of compressed air being constantly on the increase, and the rate of consumption of compressed air may be taken as well as anything which has been proposed as a measure of our progress in civilization.

WIND PRESSURES

Experiments have been made at the National Physical Laboratory, London, which bring out a new and practically very valuable fact—namely, that pressure is not the same on large surfaces as on small experimental models. If, for example, a given wind velocity is brought to bear on a square foot of surface it will be 18 per cent. less per square foot than if it were directed on 100 square feet of surface. It was demonstrated, too, that this relation is constant for flat forms, however complicated. A builder or engineer who knows that a structure may be exposed to a wind of eighty miles per hour and that the pressure per square foot as determined by model is, say, x pounds, should allow for his larger construction 20 per cent. extra. The reason for this seems to be the more thoroughly reduced pressure on the lee side of a larger area.

Many years ago the Royal Meteorological Society arranged an exhibition of apparatus for measuring wind velocities. It was an extraordinary assortment of instruments, of which one only, and that a purely empirical design, seemed to achieve the object—the well-known Robinson's hemispherical cups, invented by a clergyman. So everybody made up his mind that the thing could not be done scientifically. Straightway Mr. Dines, F.R.M.S., went and did it.

The work of piercing the tunnel through the Tauern Mountains in the Tyrol, a few miles south of Gastein, has just been completed. The tunnel is five and a half miles long and the work has taken six years. It is the last important work in the series of Alpine railways. The new tunnel alone shortens the distance between Salzburg and Trieste 110 miles.

HIGH PRESSURE GAS DISTRIBUTION

At a recent meeting of the Institute of Civil Engineers, London, an interesting discussion occurred upon the above topic.

Mr. A. J. Martin drew attention to the fact that, notwithstanding high distributing pressure, the leakage, comprised in the unaccounted for gas, continued low. He had learned by inquiry that at Aurora, Ill., where a distributing pressure of 15 pounds per square inch had been used—it was being increased to 50 pounds—there had been no trouble from excessive leakage. With higher pressures of distribution it seemed likely that small gasworks would disappear, and the supply be taken over by the larger works some distance away, which had better facilities for obtaining cheap coal. Regarding a gas distributing system as a power distributor from a central source, he would go farther than Mr. Carpenter, and say that it was cheaper than an electricity distributing system. The weight of copper required to convey a certain power electrically was greater than the weight of the steel mains required to convey the same power the same distance by gas at high pressure. The relative prices of copper and steel made the comparison very favorable to gas. Further, it must be remembered that the cost of the copper was doubled or trebled by the cost of insulation. The loss of current in transmission was 10 to 20 per cent. against 2 to 3 per cent. loss with gas; 4-inch gas pipes at 60 pounds pressure would serve to convey gas equivalent to the 4000 kilowatts which the London County Council's electricity supply scheme had proposed to send on the average from Greenwich to each of twenty-nine substations. The cost of the cables and ducts had been estimated at £666,000; the 4-inch gas pipes would cost only £43,000, and would transmit the same power. The cost of the coal used by the London Electricity Supply Companies was often greater than the cost of the equivalent quantity of coal gas—at the price now charged by the South Metropolitan Gas Company. The gas companies should be freed from all restrictions, so that they might have a free hand to supply that gas which they found most suitable for their customers.

Mr. W. J. Dibdin, F. I. C., thought the use of gas at high pressure a great advantage for heating purposes in laboratories.

Mr. T. S. Lacey, of the Gas Light and Coke Company, said that from the first it had been necessary to pump gas from Beckton to London, as the holder pressure was quite inadequate when the distance to be traversed was so great (10 to 12 miles). At the stations in London there were pumps for taking the gas from, or putting it into, the 48-inch high-pressure mains, according to the immediate requirements. A higher distributing pressure would be a great advantage to users of the incandescent burner.

Mr. A. Auden said that he had found gas at high pressure very good for lighting purposes in a factory, but troublesome for keeping type-metal melted, and he had eventually put in a low-pressure service again for the latter purpose.

Mr. W. King reported that he had found it necessary to introduce high-pressure distribution at Liverpool as early as 1878, and by degrees they reached a pressure of 40 to 45 inches. They had used Beale's exhausters for pumping. For the pipes he used entirely bored and turned joints, as introduced in Liverpool in 1826 by his father.

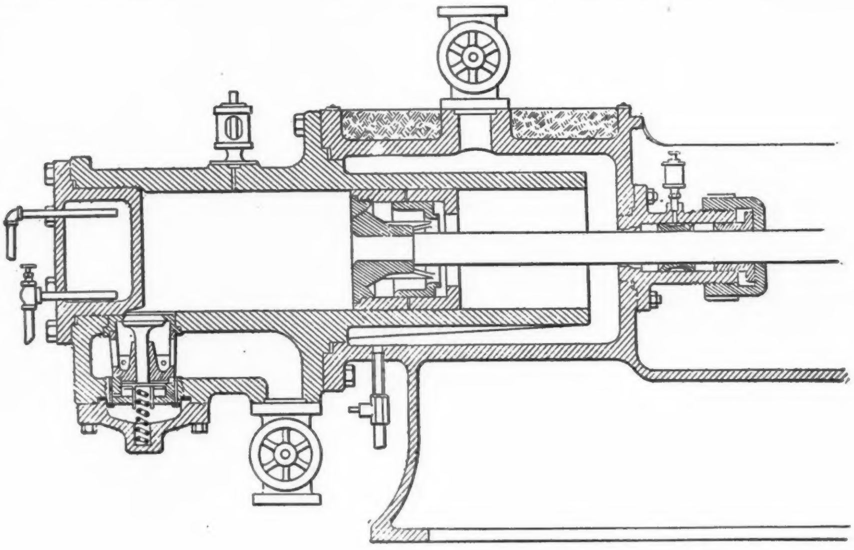
Mr. Dolby having mentioned an instance of an explosion due to gas escaping from a water-slide pendant in a consumer's house, when it was supposed that the distributing pressure had been increased in order to fill balloons with gas, Sir George Livesey said that the South Metropolitan Gas Company was altering all water-slide fittings in its district in order to make them safe. Pressure could not be increased to any considerable extent while these fittings remained in use. Then, again, the meters needed some adaptation for use with the higher pressures. It was essential, however, that the consumer should get a higher pressure. Strangely enough, the time at which the South Metropolitan Gas Company found it most difficult to maintain adequate pressure in the mains was between 11 and 12 o'clock on Sunday mornings, when so many dinners were being cooked.

Mr. Carpenter said that Sir George Livesey had already answered for him some of the points raised in the discussion. The amount of gas sent out by his company was at a maximum equivalent to about 500,000 horsepower per hour if used in gas engines. The chicken incubator was an illustration of the practicability of maintaining a uniform temperature by regulation of a gas flame.

RIDER AMMONIA COMPRESSOR

This compressor is of interest in itself for its novelty of design, and also as calling attention to the difference in conditions when compressing ammonia gas for refrigeration purposes and when compressing air to be used, as it mostly is, as a power transmitter. In either case the same theoretical condition prevails: it is desirable to fill the cylinder as full as possible at the beginning of the compression stroke, and the fluid to be compressed should be at as low a temperature as possible. It happens, however, that while air comes to the compressor at about the temperature of the atmosphere ammonia, after absorbing heat generously in the act of re-evaporation, still returns to the compressor at a temperature often about zero. The absurdity, then, of water jacketing the cylinder which is to receive this cold ammonia is apparent. The water in such a case of course acts as a heater rather than as a cooler, and by increasing the ammonia volume adds to the power cost of the compression.

The cylinder here shown in section is surrounded by the cold ammonia, and each charge enters the cylinder without coming in contact with any other than the coldest surfaces. The gas passes through the piston by a passage equal to about 25 per cent. of the cylinder area and is compressed in the left hand end. There



COMPRESSING CYLINDER OF RIDER AMMONIA COMPRESSOR.

is no heating of the gas to a temperature that would make a water jacket effective until near the end of the stroke, so that only the cylinder head has such a jacket or is made hollow so that a considerable body of water is constantly circulating in it. The inlet valve in the piston opens autward so that it is not possible for it to get into the cylinder; it is without springs but is cushioned by the gas to prevent shock.

The discharge valve is located, as seen, in the bottom of the cylinder to allow the escape of any liquid which might enter during the dry compression process, or if the machine should be used as a wet compressor this drainage valve prevents the likelihood of liquid ammonia re-evaporating in the clearance spaces. Also any liquid which may come over in the suction is discharged ahead of the gas. It will be seen that the piston rod stuffing box is exposed to little pressure and therefore is easily kept tight. The rod and the cylinder are oiled in the usual way with automatic sight feed lubricators. The stroke is long and the piston travels close, so that the clearance is very small, an important thing in this service. The steam ends of these compressors are of the Corliss type and give high efficiency.

This compressor has been recently patented by Mr. Frank A. Rider, Pittsburgh, Pa.

A large gas engine rated at 1,650 horsepower at 107 r. p. m. when using furnace gas at 80 B. t. u. has recently been completed by the Wm. Tod. Co., for the Ohio works of the Carnegie Steel Co.

THE FOG SIGNAL PROBLEM

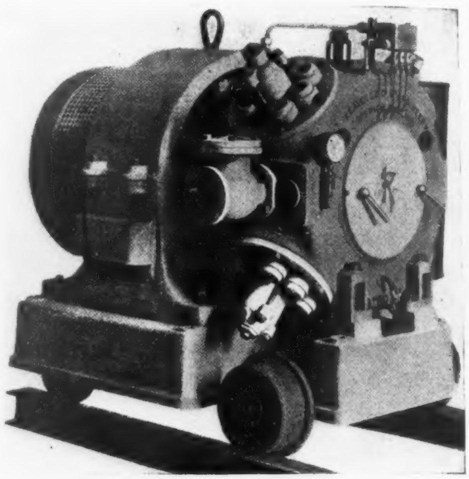
Every lighthouse of any importance on our coast has some sound-producing apparatus for a fog signal, a bell, a whistle, a Daball trumpet, or a steam syren. The sound produced, with its periods of intermission, serve to distinguish each fog signal from any other sound in its neighborhood. Fog signals are a most unsatisfactory device especially on account of the uncertainty as to the audibility of them under different conditions of sea and weather, and also the difficulty of determining the direction of their location.

The list of cautions to mariners published by the Lighthouse Board are almost funny in the suggestions of uncertainty as to fog signals. A mariner should not assume that he is out of hearing of the fog signal because he doesn't hear it, nor because he hears it faintly assume that he is far from it, nor assume that he is close to it because he hears it plainly, nor assume that he is in a given place because he hears the sound the same as he did on a former occasion when there. He must not assume when he no longer hears a signal that it has ceased to sound. He should not expect these aberrations of audibility of one signal to be the same with any other. He should not expect to hear a fog signal well when there is a swiftly flowing stream between him and it or when wind and tide are in opposite directions. These are only a few of the points mentioned.

The *Scientific American* states the problem of the fog signal as follows:

"To invent or discover a sound-producing apparatus, no more complicated or expensive, or but slightly more so, than those in use, which will be heard uniformly at uniform distances, exception being made in favor of sounds swept away by a heavy wind; or to invent or discover a means of improving present fog signals, as a resonator or reflector, which will so amplify, direct, reflect, or otherwise project the sound that it will not be subject to the aberrations above described, saving that caused by a heavy wind. There is a wide market ready for the invention which solves this problem.

"The problem has another side: It is not enough to warn the mariner of a danger, or point out the course, by a sound; it is necessary to provide him with a means of finding the direction of the sound. Can you locate a cricket? In a fog the sound seems to come from all directions, unless it is right on top of the vessel, and then the inevitable collision results. The very fact that in spite of warning apparatus of the greatest power collisions frequently occur, shows that some method is needed to definitely locate a sound.

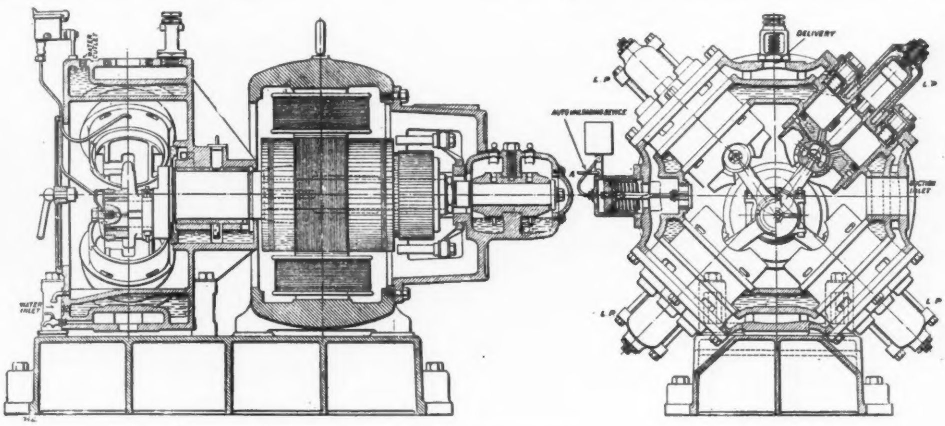


EFFICIENCY TESTS OF REAVELL AIR COMPRESSOR

The illustrations herewith and the following data obtained from actual tests we adapt from a recent issue of *Engineering*, London. The compressor, it will be seen, is portable and direct driven by an electric motor with four radial single-acting air cylinders, whose pistons are actuated from a single crank on the motor driven shaft. The compressor was built for driving reciprocating coal cutters in an English coal mine.

The interesting debate on air compressors which took place at the Engineering Conference turned largely upon the question of the relative efficiencies of turbo and reciprocating machines. The difficulty of making exact tests, and the difference of opinion which exists as to the proper way in which efficiency should be measured, account for much of the confusion by which the subject is surrounded. If the heat generated during compression could be continuously extracted, so that compression was isothermal, the work done would be a minimum, and the efficiency, consequently, the highest possible. Isothermal compression is quite impossible of realization, though the ideal forms a convenient basis for comparison. On

the other hand, one may assume no heat abstracted, and compute efficiency, therefore, on the basis of an adiabatic compression. This is in a sense fairer to the machine, but not so good a guide to the purchaser, particularly if he wants to use his air cold. A third method is that used by Professor Rateau, by which, in the absence of water cooling, the efficiency is deduced from the temperature rise of the air in passing through the machine.



REAVELL AIR COMPRESSOR.

Rated size of machine............	230 cub. ft. of free air per minute.
Diameter of cylinders............	10 in.
Length of stroke (effective)........	4¾ "
Average revolutions per minute...	325
" delivery pressure.........	70 lb. per sq. in.
" volts.....................	460
" amperes...................	68
" electrical horse-power....	42
Motor efficiency..................	88 per cent.
Brake horse-power.................	36.9
Capacity of air-receiver....	93 cub. ft.
Revolutions taken to fill receiver (Full pressure being maintained all the time in auxiliary receiver.)	595
Mean temperature of air in the receiver..........................	100 deg. Fahr
Mean temperature of air in suction	65 " "
" " at delivery of compressor.................	160 " "
Equivalent volume of free air delivered into receiver per minute..	237 cub. ft.
Equivalent volume of free air reduced to 65 deg. Fahr............	222 "
Volume swept by pistons of compressor........................	255 "
Actual mean effective pressure from diagram at 65 deg. Fahr. inlet and 160 deg. Fahr. outlet temperature.................	30 lb.
Theoretical power required from this diagram.....................	29.1 horse-power
Apparent volumetric efficiency based on time taken to fill reservoir against full pressure $\frac{237 \times 100}{255}$	93 per cent.
Real volumetric efficiency corrected to atmospheric temperature $\frac{222 \times 100}{255}$	87 "
Over-all efficiency $\frac{29.1 \times 100}{36.9}$	79 "
Mechanical efficiency by deduction,..........	91 "
Isothermal mean effective pressure	25.74 lb.
Theoretical power assuming isothermal compression	24 horse-power
Thermal efficiency $\frac{24 \times 100}{29.1}$	82½ per cent.
Absolute efficiency from actual power on shaft to isothermal diagram............................	65.2 "

From the above it will be seen that the efficiency on the basis of isothermal compression is over 65 per cent., while the efficiency calculated after Professor Rateau's method is 79 per cent. This latter is termed by Messrs. Reavell the "actual efficiency," and takes into account leakage and clearance losses. This is undoubtedly good for a machine dealing with only 230 cubic feet of air per minute.

RECIPROCATING AIR-COMPRESSORS.

By W. Reavell.

I propose in this note to deal with the features which are necessary to obtain high efficiency in a reciprocating air-compressor. With the exception of low-pressure unjacketed machines, such as blowing-engines, the observations are applicable to all compressors within the limits of pressure ordinarily met with.

The losses to which an air-compressor is subjected may be divided into three heads, namely, thermal, mechanical and volumetric, and I propose to examine these in their order.

Thermal Losses.—In an ideal compressor, all the heat generated by doing work on the air in compression would be abstracted and the

compression curve would be isothermal, the enclosed area of the indicator diagram representing the work done being then the smallest possible. In order to approach this ideal in practice, water-injection, water-jacketing, and intercooling may be used.

I have referred to water-injection first as it was one of the earliest methods adopted, but it is now rarely met with in modern practice. To be most efficacious the water should be introduced in the form of a fine spray during compression, and this involves the use of a pump. Moreover, if the quantity used is limited to that required to be converted into vapor, it is clear that the air could not be cooled below 212 deg. F., while if a pump is avoided and the water added more freely during the suction-stroke, it becomes a source of danger in a quickly reciprocating machine, and requires provision made for its removal after compression.

The efficiency of water-jackets (neglecting variations in temperature of jacket-water, and assuming a constant supply) depends upon the thickness of the cylinder-walls, the ratio of cylinder cooling surface to piston area, and the piston speed. Hence a compressor having one large cylinder will not be so efficient as one having a number of smaller cylinders, assuming the piston speed to be the same.

For the same reason a single-acting machine will have a higher thermal efficiency than a double-acting compressor, as each alternate stroke is an idle stroke, so that the mean temperature of the cylinder walls will be obviously less and the heat will be abstracted better.

Intercoolers.—When compression takes place in more than one stage, an intercooler should be placed between the cylinders, and should be proportioned so as to reduce the air as nearly as possible to the temperature it had on first entering the machine. The result is naturally to reduce its volume considerably and to reduce the power required during the next stage of compression.

Although from the point of view of volumetric efficiency it is desirable, it is mainly for thermal reasons that intercoolers are used, and, other things being equal, the larger the compressor, the lower the pressure at which it becomes economical to compress in two or more stages instead of one.

Volumetric Losses.—The volumetric efficiency of a machine is the ratio of the weight of delivered air to that represented by the piston displacement, and the losses which impair this efficiency are due to clearance, valve-resistance and leakage.

The greater the clearance between piston and cylinder head at the end of the stroke, and the greater the cubic contents of the valve passages, the greater will be the ratio between the piston displacement and the air actually delivered per stroke; and on account of the necessity of making provision for wear this loss is greater in double-acting than in single-acting compressors.

Valve Resistance.—With spring-loaded suction valves the air pressure in the cylinder during the suction stroke is less than that of the atmosphere, owing to the resistance of the springs, and hence the importance of using mechanically-operated suction valves which give a free admission of air during the suction stroke. With spring-loaded delivery valves, there will be a slight increase of pressure in the cylinder as compared with that in the delivery pipe, depending on the design of the delivery valve and the strength of the spring. This excess pressure has usually no appreciable effect on the volumetric losses, but it does, together with the attenuation losses on the suction side, increase the area of the indicator-diagram and increase the power required to drive the machine. Volumetric loss from leakage is traceable to piston rings, stuffing boxes, and defective valves.

It is undoubtedly equally as important in air-compressors as in steam engines to pay careful attention to the design of piston rings; and if all compressors were always tested for volumetric efficiency many a machine which was credited with an excellent performance, judged from the indicator card, would be found to owe the resemblance of its compression curve to the isothermal curve more to leakage of air past piston rings than to excellence of water-jacketing. Experiments I have carried out showed that, in small compressors, a considerable improvement in efficiency was obtained by fitting piston rings of the Willans type instead of "sprung on" Ramsbottom rings.

Mechanical Losses.—The mechanical efficiency of a compressor is represented by the ratio of the work done, as shown by the indicator-diagram in the compressor cylinder, to the power actually applied at the crank shaft to operate the compressor. These losses are of course frictional, and are due to piston rings and stuffing boxes, slippers, guides, bearings,

and questions of alignment when more than two bearings are used.

Valves.—I have already referred to the advantages of mechanically-operated as compared with spring-loaded valves, and to give the large opening required for admitting air to the cylinder without attenuation, the mechanically-operated suction valve is preferable. For delivery valves the mechanically-operated type is not as frequently met with, because of the difficulty of readily adjusting it for different delivery pressures.

Governing.—An important matter to consider in connection with air-compressors is the varying of the power exerted, in accordance with the demands for air, and so as to maintain the air pressure as constant as possible. When the compressor is steam-driven, the speed of the machine can be varied automatically by a valve operated by slight variations in the air pressure; but when the compressor is driven at a constant speed other means are necessary. If the machine is belt-driven an automatic appliance should be fitted, operated by fluctuations in pressure to move the belt from fast to loose pulley.

When electrically driven, the machine can be fitted with an automatic switch to stop and start it in accordance with the changes in pressure due to variation of demand. It is essential with these two methods to have a very large reservoir compared with the capacity of the machine, and hence many machines are fitted with an unloading device which enables the machine to run nominally without load. These operate by holding the suction-valve open during the delivery stroke, or some similar method.

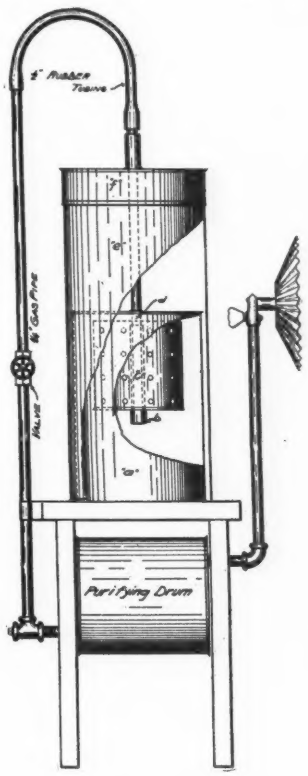
This method, which may be termed the "all or nothing" method, is not very satisfactory, especially for electric driving, as it gives such fluctuating loads to the motor, and methods of varying the volume will undoubtedly be perfected by compressor designers to meet this defect.

The motor used by M. Santos Dumont in his recent more or less successful attempt to fly with an aeroplane weighed slightly more than two pounds per horsepower.

The total excavations from the Panama canal during June, according to a report from Chief Engineer Lieutenant-Colonel Goethals, was 780,957 yards

A PORTABLE ACETYLENE MINE LAMP

The sketch herewith, which we reproduce from the *Mining and Scientific Press,* shows a lamp in common use in Mexican mines. It is a home-made affair, but is said to be quite satisfactory, and on account of the cost of other illuminants acetylene lamps are quite numerous. This type of lamp was used continuously in one Mexican mine while air connections were being made.



ACETYLENE LAMP.

Acetylene requiring less oxygen than other illuminants, it was found that faces could be worked where an ordinary lamp or candle would not burn. In large stopes it also proved satisfactory, since the amount of light furnished by one lamp was greater than that of a number of candles or a torch and, the lamp being portable, it could be moved from place to place, wherever light was most needed. The lamp can be cheaply constructed; any tinsmith or ordinary mechanic will have little difficulty

in making one out of ordinary galvanized iron and a few pieces of pipe.

The method of charging the lamp is as follows: The rubber tubing is first disconnected and the cover *f* is removed; the gas-drum *a* containing the carbide-drum is now removed and the cap *b* unscrewed. The carbide-drum can now be slipped off and is filled with about 2 pounds calcium carbide, which should be in rather large lumps. The carbide-drum is now put back into place and the water cylinder *e* is about half-filled with water; now carefully lower the gas-drum into the water, being careful not to allow the carbide to touch the water until the cover *f* is replaced and the rubber tubing is connected. The small valve in the pipe leading to the purifying-drum may now be opened, allowing the air to escape through the drum and gas-jet. As soon as the air has all escaped the drum containing the carbide will come in contact with the water and acetylene gas will be generated. This gas enters the gas-drum *a* and finds its way into the pipe by way of the small hole *d*, and passes into the purifying-drum which is packed with cotton-waste, which will take up any small particles of dust. From the drum the gas passes into the pipe fitted with a Stewart patent gas-tip.

The lamp is self-regulating, for as soon as more gas than can be immediately used is generated, the pressure of gas will raise the gas-drum *a* and, the carbide-drum, being attached to the other drum, will be lifted out of the water and no more gas will be generated. As the gas is used up, the gas-drum with the carbide-drum will settle down into the water again and more gas will be generated. The lamp being self-regulating, little attention need be paid to it after charging and starting.

HEAVY FUEL OILS

One dollar will buy a little over nine times as many heat units worth of crude oil as of gasolene, which would make its use far more profitable were it placed on the same basis of efficiency. Yet with the exception of a small number of large stationary motors, and a few portable motors of the farm implement type, the heavy oil consuming motor is not to be found. Certainly for the automobile type it does not exist. Setting aside the somewhat rare examples of stationary practice, most experiments which have been made up to this time in the way of the adaptation of the internal combustion motor to the use of heavy oil fuels have been directed at the carburetting apparatus. Yet it is by no means certain that such fuels can be carburetted in the ordinary sense. Certainly, the long delayed results of some of the experiments which have been made show that it is no simple matter, despite its apparent simplicity. A high degree of heat is required to complete the vaporization of the fuel, and a higher ignition temperature is necessary than with gasolene. These considerations, together with the more or less viscous nature of the fluid itself, render the use of the ordinary aspirating spray principle extremely difficult. On the other hand, the introduction of the fuel directly into the combustion chamber, after the manner made possible by the use of the mixing valve, or by the method of injection into a body of compressed air, is both unexplored and, in the latter case at least, attended with more or less mechanical complication. These difficulties, however, are not of necessity insurmountable, In fact, they are in no way comparable to some that have been overcome already.

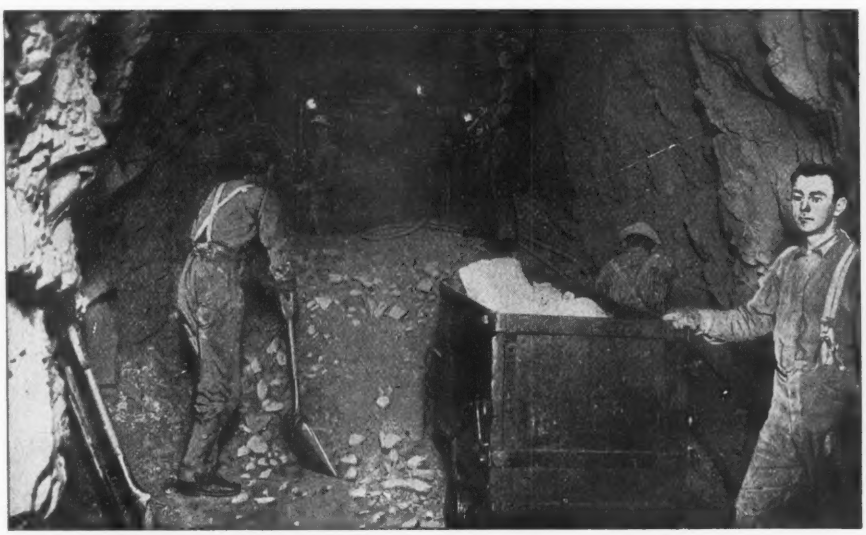
COMPRESSED AIR FOR CAR CLEANING

At the recent meeting of railroad men at Atlantic City, a long discussion was had upon the cleaning of cars. It appeared that the cleaning of passenger coaches, and especially of sleepers, is quite a complicated operation and various devices are employed for the different details.

Mr. C. A. Schroyer of the Chicago and North-Western said: "There is something wrong with us when we come to cleaning cars and the cost of doing it. We clean about 400 cars a day in Chicago. We have one yard fitted up in what we consider a modern manner, with steam, with air, and with water. We use straight air for blowing out the dust upon the varnish and in the blinds and curtains, blowing it out of the cushions and backs, after first raising the windows and opening the doors of the cars, and if you get outside of that car when the work is being done you will see a cloud of dust being turned out of the car, but it is settling somewhere else. Now, what elements there are in that dust that might carry disease we do not know, but we do know that our car cleaners are a pretty healthy gang of

men and women. I have thought a great many times that I would like to have the vacuum system, but we cannot have it in our yard unless we use it in connection with the straight air system, and we think that that costs us too much money, because straight air is pretty expensive. I have again thought that it would be wise to use the vacuum system in connection with steam, running steam pipes out into the yard and producing our vacuum."

Another speaker said: "I believe the almost universal practice at large terminals is to use the compressed air system for inside cleaning of passenger equipment, although I know of one or two instances where the vacuum system is being used. From what I have observed, and from conversations with others, I am led to the belief that the vacuum system is not as well adapted for the floors and carpets of cars as the compressed air system, but for seats and draperies the vacuum is probably preferable. In order, therefore, that the really up-to-date cleaning of cars can be obtained, a yard should be equipped with both systems, because cars could be cleaned better and in less time.



THE HEADING—SHOWING MUCK PILE CAR AND SHEETS IN OPHELIA TUNNEL.

RECENT PRACTICE IN TUNNEL DRIVING*

By W. P. J. Dinsmoor.

*Condensed from *Mines and Mining*, June, 1907.

The Ophelia Tunnel in the Cripple Creek District of Colorado was driven for the purpose of draining mines, and transporting ore and waste from the deep levels of such properties as it might cut.

This tunnel has been driven to a point approximately 8,500 feet in a direct line from its portal. It is for its entire length nine feet by nine feet in the clear, and in places will show ten feet by twelve feet.

The tunnel was driven through granite, then into breccia, with intervening dykes of phonolite, andesite, and nephaline bassalt, at an average rate of 350 to 375 feet per month. Three hundred and fifty feet per month was considered low, and such a result called for an investigation by the management of the causes which reduced the work accomplished to this figure. The record month showed an advance of 395 feet and 8 inches. This speed in driving was obtained by careful planning of the work, so that there would be no loss of time or idleness for either the men or equipment. This required a thorough study of the conditions to be met and overcome, and careful oversight. The plant consisted of two 60 horse-power boilers; one straight line, two-stage air compressor; one high-pressure, three-stage, locomotive-charging compressor; one Porter compressed air locomotive and Sullivan 3⅛-inch drills.

PLAN OF WORK.

The working day was divided into three

shifts of eight hours each. In the actual tunnel driving work there were seven men to a shift; two machine drillmen, two machine helpers and three "muckers." Each shift was supposed to drill, load and shoot a round of from eighteen to twenty-two holes, drilled from 5½ to 7 feet in depth, as well as to load the "muck" resulting from the work of the previous shift into the cars, and deliver the cars to the compressed-air hauling engine. The management feels that under the three-shift plan the men do better work and take more pride in its results, owing to the fact that the men know that another shift is following close on their heels to perform the same operations that they have performed, and that the following shift depends upon the satisfactory completion of this shift's work for the accomplishment of their own.

The method pursued was essentially as follows: As soon as the smoke was cleared, the new shift of drillmen, helpers and "muckers" all went to work, and the broken rock from the face was thrown back sufficiently to allow the columns for mounting the drills to be put in place. The two drillmen worked together, and the two helpers worked together in pairs, relieving each other at intervals; the "muckers" going immediately to work, getting the "muck" into the cars and on its way to the dump. When the helpers were working on the muck pile, the drillmen were back of the work; looking up equipment; seeing that all the machine drills, steel, hose, tools, blocking, etc., that would be required for the shift's work were on hand, and, if anything was found missing, taking steps to secure it. When the drillmen were working on the muck pile, the helpers were employed in bringing the required material up to the face, where it would be readily available.

It may be objected that this would be possible only in a short tunnel, but in this tunnel, about one and two-thirds miles long, this work was accomplished by each shift every day. As soon as the muck was cleared away from the face, the columns were put in place; the drills mounted, and the drilling of the new round commenced.

In clearing away the muck, care was taken that it should not fall back toward the face until a sufficient space was provided in which to set the columns. After the columns were set the muck was allowed, and in fact encouraged, to fall back, until it had filled the space in front of the face up to such a level that the tops of the jack screws of the columns could just be reached. By this method, the back holes, or those nearest the top of the tunnel, were the first to be drilled, and the drillmen and helpers worked from the top of the muck pile. This did away with any form of staging, and while the drillmen worked towards the bottom of the tunnel, the muckers were removing the pile, thus always giving the drillmen a standing ground of proper height, or really a self-adjusting platform, much wider and more solid than any portable timber staging. It was of course necessary for the muckers to finish loading out the muck before the drillmen reached the bottom holes or "lifters," but they did not stop work until the end of the shift was reached, as there was rail laying, and the placing of sheets, to occupy their attention until the holes were loaded and ready for shooting. Everyone on the shift was busy from the time he reached the heading until the holes were loaded and fuses split. The only time lost in the twenty-four hours of the day was that required for changing shifts and the clearing of powder smoke.

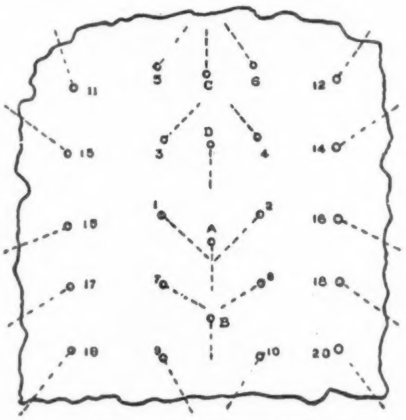
Full length mining columns were used in order to reduce the amount of blocking needed at the top and bottom of the columns, and to insure the removal of the muck from the face, clear to the bottom of the tunnel before the set-up, so that resetting would not be required when the bottom holes were reached.

Care was always taken to see that the men were well supplied with all material for their work. Empty cars were always kept at the face; an extra machine drill was constantly on hand, so that if one of the drills in use required repairs, it could be laid aside, to be put in order by a skilled mechanic. Thus the drillman and his helper were not delayed by making repairs. Plenty of sharp drill steel and water for use in the holes were kept close to the face.

ARRANGEMENT OF DRILL HOLES.

The important matter of properly placing and shooting drill holes was carried on as follows: In the illustration, holes Nos. 1 and 2 are cut looking down, and were so placed and directed that their inner ends nearly met. The fuse for these holes was so cut that they were fired first and nearly at the same moment. Holes Nos. 3 and 4 are cut holes, drilled looking up and about the same depth as Nos. 1 and 2. They were so directed that their inner ends

did not meet, as in the case of Nos. 1 and 2. The fuse was so adjusted that these holes were fired just after Nos. 1 and 2. Holes Nos. 5 and 6 are the back cut holes. They were drilled looking up, and so directed that their inner ends did not meet, nor did they extend together beyond the top of the tunnel. These holes were shot together and just after Nos. 3 and 4. Cut holes Nos. 7 and 8 look down, and were timed to shoot after Nos. 5 and 6. Holes Nos. 9 and 10, the cut lifters, look down and extend below the proposed bottom of the tunnel. Holes Nos. 11 and 12, the back rib holes, and holes Nos. 13 and 14, rib holes, look up. Holes Nos. 15 and 16, also Nos. 17 and 18, rib holes, and holes Nos. 19 and 20, rib lifters, all look down and all extend beyond the line of the side walls, and were all shot at nearly the same time.



ARRANGEMENT OF DRILL HOLES.

Where stiff ground was encountered holes A and B were put in, and shot with holes Nos. 1 and 2 and Nos 7 and 8 respectively. Where very stiff ground was found, holes C and D were added and shot with holes Nos. 5 and 6 and Nos. 3 and 4 respectively. By analyzing the above it will be found that holes Nos. 1 and 2 take out or loosen a wedge-shaped portion of the rock, thus relieving the resistance to the action of the powder in holes Nos. 3 and 4 and holes Nos. 7 and 8. Holes Nos. 3 and 4 and Nos. 7 and 8 clear the way for holes Nos. 5 and 6 and Nos. 9 and 10. Holes Nos. 9 and 10 have a tendency to throw any broken rock above them out of the way of the remaining rib holes. Holes A, B, C, and D serve simply to increase the effect of the holes with which they are shot. By placing the holes in this way and shooting in this order, the break, with very few exceptions, always cleared the rock for the full width and depth of the tunnel, thus doing away with the necessity of following the heading with any work designed to break off projections.

Tamping material for use in the loading of the holes was always employed. It was found that by using this, the results obtained were most satisfactory, and that less powder was consumed.

HANDLING THE MUCK.

Two tracks were maintained close to the heading. Before the shots were fired, steel sheets were placed on the floor close to the face, extending back far enough to receive all the broken rock. It was found important to have these sheets weighted, and enough muck was kept at the face to do this properly. The sheets formed a smooth floor from which to shovel the muck, but unless the sheets were weighted, it was found that the vacuum created by heavy shots was likely to lift them and mix them with the muck, thus not only defeating the purpose for which they were intended, but actually increasing the labor of mucking. The sheets behind the main portion of the muck pile served to receive part of the muck thrown from the face, and also to facilitate the handling of cars.

A convenience for saving time was the use of a flanged valve on the heading end of the pipe line, instead of the screw valve commonly employed. There was also a telephone system, one station of which was kept well up toward the heading. In case of accident, or when it was necessary to communicate with the portal or power house, the use of the telephone saved valuable time.

VENTILATION.

The removal of powder smoke after shooting was accomplished by means of a blower and the compressed air system. As soon as the work of drilling stopped, the engineer would notice the fact that the demand for compressed air had ceased; he would then fill the receivers and pipe lines with air at 100 pounds pressure. After the holes were loaded and fuses split, the drillmen would open the gate valve at the heading, allowing a full stream of air under 100 pounds' pressure to play on the face through a 1-inch whistle cock. This volume of air, coming with a high velocity, stirred up the smoke and mixed thoroughly with it. The pressure in the pipe lines dropped rapidly

and as soon as it reached twenty pounds the engineer started the compressor and kept the pressure up to that and also started the blower, if it was not already running. A 15-inch ventilating pipe was used and the smoke was soon thoroughly mixed with fresh air. It was seldom that the men could not get to the face twenty minutes after the shots were fired.

For various reasons the costs for this tunnel cannot be given, but figures shown by the management compared with figures for other tunnels driven under similar conditions of ground, cost of labor, fuel, powder, etc., show the cost of this tunnel to have been very low. The men were well paid, but no bonus was given for progress above the average rate per month. The work was done thoroughly; the alignment and grade of the tunnel were kept perfect and it would seem reasonable that it was the methods employed which assured the rapid headway and the low cost per foot.

OIL PNEUMATIC GOVERNOR

The function of the governor here illustrated and described—designated as Type N and manufactured by the National Brake and Electric Company, Milwaukee, Wis.—is to automatically control the operation of an air compressor driven by a series wound motor, stopping it when a predetermined maximum pressure is reached, and starting it again when the pressure falls to a predetermined minimum. It works automatically by making and breaking the electrical circuit to the motor as the pressure reaches the limit upward or downward. It is a purely pneumatic governor, no troublesome magnets or complex levers being employed. The only electrical features are the two terminals and the switch-arm which makes the connection between the terminals.

Fig. 1 is an external view of the governor complete; Fig. 2 is a vertical longitudinal section, and Fig. 3 is a plan of the apparatus with the cover removed. The external dimensions of the case are 15x7⅜x4⅛ inches. This case is constantly filled with oil, its capacity being three pints. Any good quality of mineral or transformer oil free from carbon, fishy or other organic matter, may be used. The oil entirely surrounds all working parts, preventing rust and wear, and it thoroughly suppresses the arc which follows the breaking of the electric circuit. There is no deterioration of the oil in use and it will last for years without replacement. The containing structure of the governor permits ready access to the mechanism for adjustment by those authorized, but not by a meddlesome motorman.

CONSTRUCTION.

Into the containing case are cast the keyways for fastening the forward end of the extension operating spring (21) and the contact arm stops. The piston (12) is equipped with double cups or gaskets (24), made of a special composition, which is not affected by oil. The piston (12) works in the air chamber guided by (3) on the opposite end of the piston rod. The piston rod carries the operating spring (21) and a spring adjusting yoke or collar (19) at its forward end, to which the controlling spring is secured. The adjusting yoke is provided with a washer (20) the tension of the spring being adjusted by nut (19). The cylinder end of the spring is held in a containing box by the two keyways referred to above. These keys are shaped in such a way that the spring is held very rigidly.

FIG. 1—OIL PNEUMATIC GOVERNOR.

The cylinder is tapped directly to the reservoir, so that the piston is always subjected to reservoir pressure and no waste of air can occur. The piston rod is threaded at its lower end to receive the adjusting nuts (17) for varying the range between minimum and maximum pressures. These adjusting nuts are made round instead of square, and are adjusted by means of a spanner wrench, which militates against the temptation of a motorman with a monkey wrench, to tamper with the adjustment.

A trip hammer of the kodak shutter type and made of brass, is pivoted on a post (37) between the adjusting nuts, its function being to trip the switch arm to open and close the electric circuit. The trip hammer mechanism which actuates the switch arm is accelerated by action of the spring (29) supported on a pin (25), and fastened at one end by means of

the pin guide (30), which is supported at the trip-hammer end by means of a movable metallic block or eccentric device working between parallel jaws, cast as an integral part of the trip hammer. The other end is secured to the wall of the containing case by means of toggle pin (26), which fits in lugs cast into the governor case. A smaller, shorter spring (28) of one-eighth the power of the trip hammer accelerating spring, and separated from the former by distance piece (27), prevents vibration of the switch arm when the circuit is open.

The switch arm (18) is made of a special insulating material. Being always under oil, no deterioration of the insulating material can occur. The motion of the switch arm in either direction is limited by stops cast into the end of the containing case.

The moving switch blade contacts (39) are of heavy square phosphor bronze and are adjusted by means of screws (43) and adjusting plate (41) so that the area of wiping contact may be increased or decreased as may be required. The stationary electric contacts (10) are heavy, square plugs, and are insulated from the governor containing case by means of the heavy insulating bushings (32). Short-circuiting between stationary contacts and case is therefore impossible. The arrangement of the supporting screws for the stationary contact is such that they can be easily turned over to present a new contact for the switch blade if the occasion should ever arise, which will be rare. The two terminals for the electrical connections are placed on the side of the governor case and are thoroughly insulated from each other and the containing case by means of a

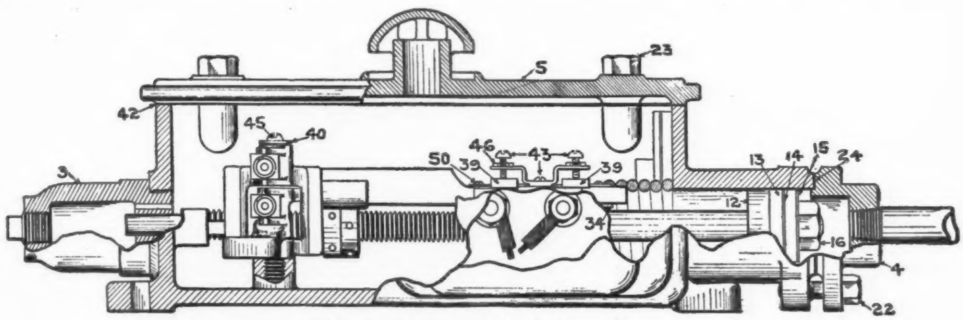


FIG. 2—OIL PNEUMATIC GOVERNOR.

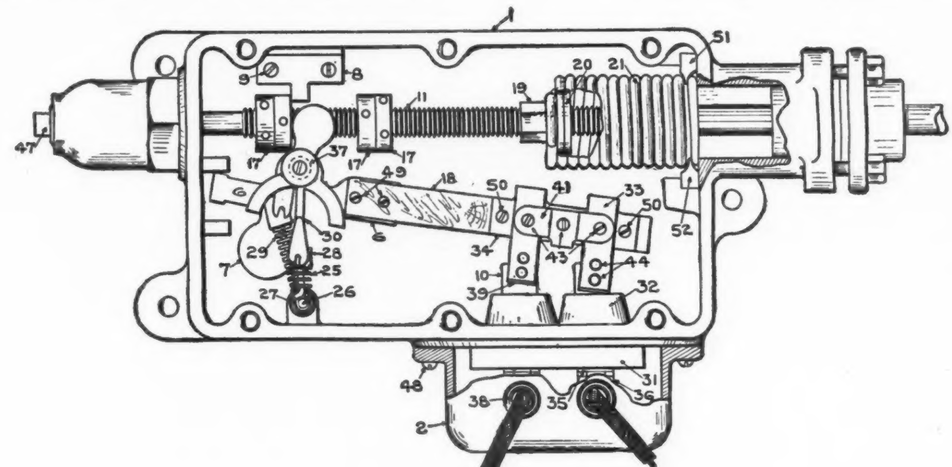


FIG. 3—OIL PNEUMATIC GOVERNOR.

INSTALLATION.

For traction service the governor may be under a car seat as directly over the reservoir as possible. For stationary service, it may be located as most convenient, but not in a vertical position. It should be connected to the

thick fibre block (31) which eliminates all danger of short circuiting. The two terminals can be either trolley or motor connection, respectively, without affecting the working so that a wrong connection cannot be made—a feature not possessed by any other governor. receiver as directly as possible to avoid compressor pulsations in the piping.

OPERATION.

This governor is equally adapted for operation by either direct or alternating current, and its performance is not affected by variations of voltage. It also is entirely independent of gravity or outside forces. When the compressor is in operation and the air pressure increases, the force of the piston at once begins to extend the operating spring. When the pressure approaches the maximum the upper adjusting nut forces the projecting end of the trip hammer over its center, causing it, with the assistance of the accelerating spring, to deliver a quick blow to the switch arm, which immediately knocks it out of contact and opens the circuit. The arc which results is instantly suppressed by the oil. The design of the trip hammer mechanism is such that its inertia is small and almost frictionless. When the air has thus acted on the piston and the pressure has been reduced this causes the operating spring to return the piston, at the same time moving the hammer over its center in the opposite direction and causing it to strike the switch arm and instantly close the circuit.

SOME LATE IMPROVEMENTS ON COMPRESSIVE RIVETERS AND OTHER PNEUMATIC TOOLS*

By Chester B. Albree,

President Chester B. Albree Iron Works Co., Allegheny, Pa.

COMPRESSIVE RIVETERS.

In compressive riveter work there are two or three types which are quite familiar, the oldest type being the straight hydraulic machine invented by Tweedel in England, and, later on, the pneumatic riveter by Allen of New York, who was perhaps the first to make it a success. Later came the hydro-pneumatic riveters. With the hydro-pneumatic riveter we have been making some experiments, and it has been found advisable for several reasons, notably for greater economy of air, simplicity of construction and better action, to try to improve the methods that have been in use. In the operation of driving rivets the pressure required differs from that for punching materials, in that in punching your greatest pressure comes at the first of the stroke, when the punch comes down on the material. In riveting, however, especially hot riveting, the easiest work is when the die first strikes the rivet and the greatest pressure is required to finally form the head. That being the case, it can readily be perceived that a constantly increasing pressure would be the theoretically correct pressure to drive rivets. This pressure is most easily obtained by means of the toggle joint, which theoretically gives an infinite pressure with an infinitesimal movement at the end of the stroke. In practice, of course, we do not get an infinite pressure; but, as most riveters are of horseshoe or yoke type, the limit pressure is the yielding point or the bending point in the yoke. In straight toggle joint machines the general idea is shown in Fig. 1.

In practice we find that when the cylinder has made seven-eighths of its stroke the pressure line of the rivet dies rises up to about fifteen times the pressure in the cylinder. By that time we would have traveled within about 1-16 inch of the end of the stroke of the machine, and beyond that point the probabilities are that there would be spring in the yoke. If we made the yoke strong enough not to spring at all, it would be so heavy as to be utterly unmanageable. So it is only necessary that deflection should not occur at a pressure below that necessary to drive the rivet. Hence in the toggle joint arrangement we have the best possible arrangement for driving rivets.

But there are certain drawbacks in the practical application of the toggle pressure. The principal one is that its stroke is absolutely fixed. It never varies for a given leverage. In riveting, you are liable to have 1 inch or 2 inches, or maybe only ½ inch thickness of plate, and in order to have the maximum pressure just as the die comes to the surface of the plate, it is necessary to adjust the distance between the die and the point of maximum pressure by means of a screw actuated by hand. In work that does not vary it makes little difference, but in ordinary structural work, and boiler work, you have constantly to drive rivets through different thicknesses of material, and

*From a paper presented before the Engineer' Society of Western Pennsylvania.

each time it will be necessary for the operator to adjust the screw. This requires a certain amount of skill, and if it is not done correctly the chances are that you will not drive the rivet sufficiently tight, if you do not close it with maximum pressure.

To overcome this difficulty of adjustment the hydro-pneumatic machine was devised, which is nothing more nor less than a hydraulic intensifier. The ram alone gives a very small but powerful motion, and as it is necessary in riveting to have clearances, in order to go over angles, stiffeners, etc., so it is desirable to have a longer stroke. Of course we do not need high pressure over a longer distance than, say, 1¾ inches. The question was then how to get a clearance movement. This was accomplished

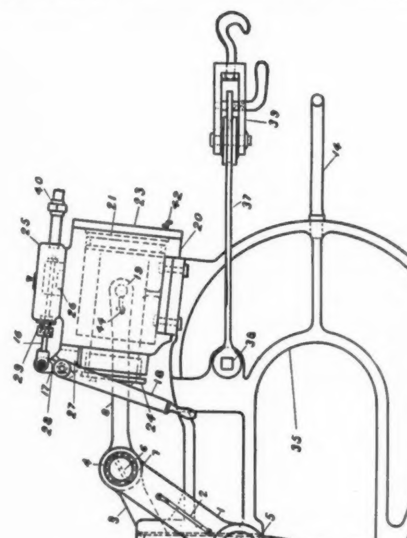


FIG. I.

by putting a little auxiliary cylinder below the air cylinder. The air pressure acting on its piston forces liquid into the ram cylinder at low pressure, and by this means we get 3 or 4 inches of preliminary adjustment.

The objections to this form are, in the first place: that it is very difficult to pack; and second, that in order to get two inches of die motion with a maximum pressure of 50 tons, it requires a 15 to 20-inch stroke in the air cylinder, and a very high pressure throughout this stroke in the ram cylinder and plunger cylinder, sufficient for the final closing pressure, thus wasting power. The practical advantage is that it does not require skilled workmen to adjust the dies; they adjust themselves. It occurred to us that we might get the desired toggle joint effect and yet have an automatic adjustment, and what I want to speak of is the device for the accomplishment of this, which may be of interest to you.

In Fig. 2 is shown our first attempt and also our perfected form. As far as the toggle joint action goes, it is practically the same as that of the first machine described. The pressure from the toggle, in the first form machine, is transmitted from the large area of the plunger to the top of the ram, and also through a pipe to the adjusting cylinder. The ram, being smaller in area and free to move, advances more rapidly than the plunger and continues until the rivet die on its extension strikes the projecting rivet. As the plunger continues, the pressure in the cylinder is limited by the pressure due to the spring in the adjusting cylinder, which is only 20 pounds per square inch, insufficient to upset the rivet beneath the ram. Hence the liquid will now displace the piston in the adjusting cylinder, the ram remaining stationary. As soon, however, as the projection on the plunger enters the ram cylinder the full toggle pressure is transmitted through the incompressible liquid to the ram, forcing down the rivet, and the differential area above forces the remaining liquid in the large plunger bore into the adjusting cylinder.

During the downward motion of the ram the liquid beneath it is forced into the opposite end of the adjusting cylinder; against the spring pressure. It is obvious that the ram may move its whole adjusting stroke, or none at all, up to the time that the projection on the plunger enters the smaller area; after which the further travel of the ram is that of the plunger until the ram meets opposition greater than the pressure of the toggle, when it will stop. This arrangement, therefore, automatically adjusts the point of maximum pressure to suit the work. On the return stroke we have the direct pressure beneath the ram, as well as the suction of the plunger, to raise the ram to its original position.

Theoretically this design was correct, and it worked very well indeed for about two strokes. At the end of the second or third stroke our packing was gone, and we have found it impossible to hold the pressures. The trouble lay in the fact that we put cup leathers at the end of

the plunger, and when the cup leathers entered the chamber the moment the pressure rose to a high point it tended to cut the leather right out. So in order to make the device practically, as well as theoretically successful, it was necessary to devise some scheme to have the leather cups, which hold better than any other hydraulic packing, move always surrounded by the walls of the cylinders, and pass no ports whatever. To do this and yet allow the liquid to pass freely from the upper to the lower part was rather a difficult proposition. We accomplished it in this manner.

closing the poppet valve. This occurs only when the port *M* leading into the space below the small piston is closed, due to its passing from the large diameter bore to the smaller ram bore. When closed, the toggle pressure acts on the liquid below the plunger extension, raising the pressure sufficiently to move the small piston and connected valve, and later exerting very high pressure on the poppet valve, shutting it perfectly tight. The adjusting action is precisely the same as in the first type, except that the liquid flows through the plunger extension instead of around it, during

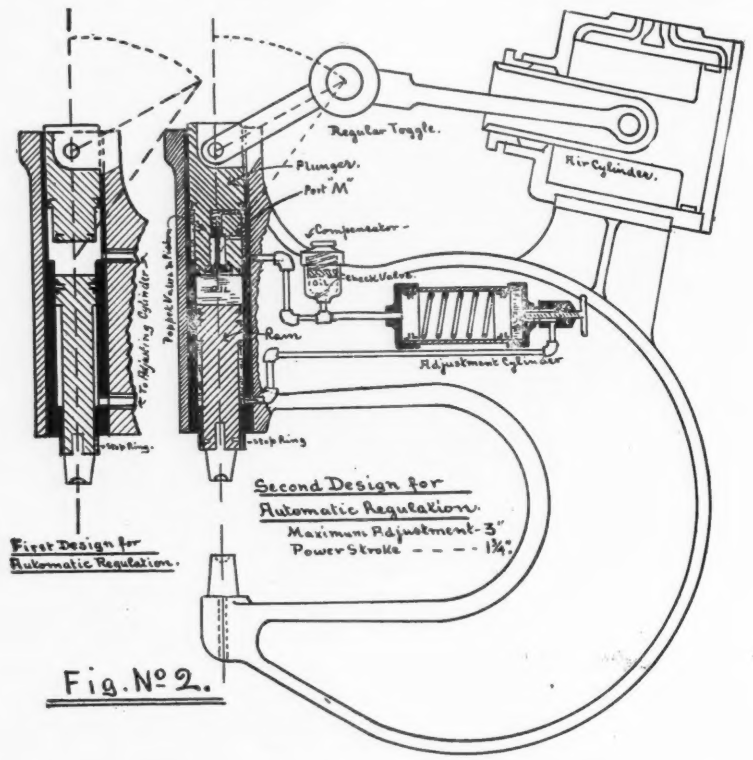


Fig. No 2.

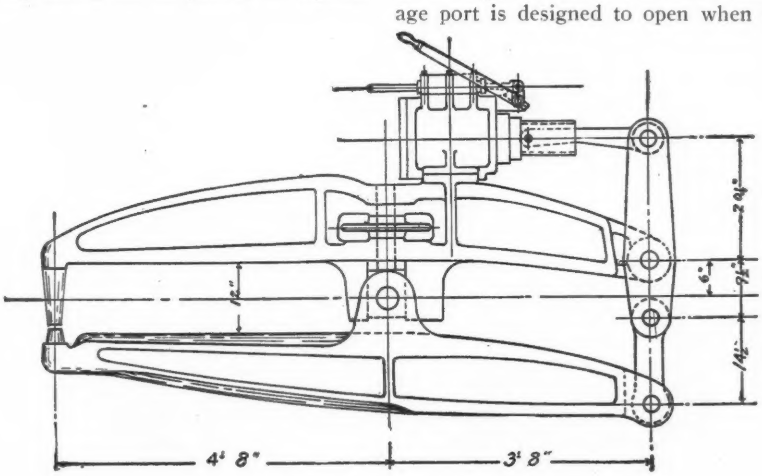
Referring to the later form in Fig. 2 it will be noted that the extension of the plunger, when fully up, projects into the smaller area of the ram cylinder, and that cup leathers are used to pack it. In the interior of this extension is a valve of the poppet type, but having a stem carrying on its end a small piston. This valve is normally held open by a spring. So long as the pressure above and below this small piston is the same, the spring holds the valve open, but when the pressure below is greater than above the piston will move up, the adjustment part of the stroke. With this arrangement it will be noticed that all of the closed by cylinder walls and pass no ports or openings, so that the packing leathers are not injured. I would say that the adjusting device is patented and the poppet valve device is now being patented.

In any device of this kind there is always a certain loss of liquid due to a film in the ram (although theoretically the quantity of liquid is constant) and in the course of a little while there would be a partial vacuum inside and

pressure on a cavity would not give good hydraulic pressure on the rivet. It was therefore necessary to provide a constant source of supply of the liquid, so arranged that when the pressure rose in the confined liquid it would not blow out, but when there was a vacuum in the system additional liquid would run in.

This loss of liquid is made up from a small storage, or compensating cylinder, full of liquid, having a piston with a spring behind it, connected to the larger bore of the plunger by a pipe having a check valve in it. Whenever there is pressure in the plunger cylinder the check valve remains closed; but when the toggle is fully back, and the piston in the adjusting cylinder is against its cylinder head, so that no pressure due to its spring is exerted on the liquid, any loss of liquid will tend to create a vacuum in the plunger cylinder, and then the check valve will open and oil will flow out of the compensating cylinder under the pressure of the spring acting on its piston, to replace that lost.

FIG. 3.—PNEUMATIC HAMMER.



Alligator Riveter - Fig-No 4.

PNEUMATIC HAMMERS.

We have been working on pneumatic hammers and have now perfected a hammer one or two features of which are novel and of interest. In pneumatic hammers of nearly all makes, one of the sources of trouble has been that if the workman picked up the hammer and put his finger on the trigger when there was no chisel or rivet set in it, the piston would begin to reciprocate, and not having any tool to strike at the lower end it would strike the cylinder head, and in a matter of a minute or two it would smash the piston or cylinder. About 75 or 80 per cent. of the breakages of pneumatic hammers are due to the carelessness of workmen in pressing on the trigger when there is no work to do. We have devised a method of obviating this trouble which is very simple.

The admission port is located near, but not at, the end of the larger cylinder bore. When no tool is placed in the end of the hammer the lower end of the large piston diameter passes and closes the admission port, thus preventing air from acting upon the differential area to lift the piston. Any compressed air below the large diameter escapes by a small leakage port to the exhaust; and this leakage port is only open when the admission port is closed. In hammers actuated by valves exterior to the piston, it seems impossible to use this device, and attempts have been made to mechanically close such valves, but they do not appear to be very successful. The same effect is obtained, but at the expense and loss of air, when the leakage port is designed to open when the piston is at the extreme end of the stroke, but does not close the admission port. Patents are now pending for these improvements.

This simple device is very effective. We can pick up a tool and with 100 pounds air pres-

sure in the pipe, put your finger on the button, open the throttle, and it does not start unless the tool is fully in place, whereas with any other tool that I know of, the moment you put your finger on the trigger it begins to work, and it is only a matter of a few minutes until it is good for nothing.

A SPECIAL RIVETER.

I might speak of another machine which was built for some special work that has a feature of interest. The work to be done was the riveting of some concrete mixers, they being in the shape of two cones with their bases placed together. The problem was to reach into a very limited space and drive the rivets. They had been doing it by hand, and wanted something a little quicker than the pneumatic hammer and something that gave tighter rivets. They wanted a power machine. It was necessary to have a reach of some 50 inches and we had an extremely small opening. At the same time it was necessary to be able to adjust for different thicknesses of material, and to give what we call an alligator motion to the jaws of the machine. The ordinary riveter could not be used for this work.

To secure adjustment of the projecting alligator jaws of the machine, we inserted a screw carrying the trunions of the fulcrum on one end. A hand wheel, with thread in the hub, serves to raise or lower the screw, thus adjusting the distance between the ends of the jaws as desired, and at the same time not interfering with their clearance or action. The details of the machine are plainly indicated in the cut. It is provided with a universal bail, so that it can be used in any plane at any angle.

We also designed a special carriage to hold the double cones, rendering it unnecessary to raise either riveter or cones, but only to revolve the cones on their axes.

I might mention one other thing which I believe will not be quite new to you, and that is a method of riveting boilers in a horizontal position. We made a wheeled truck carrying on its bed three sets of rollers running in the opposite direction. We suspended from a trestle a riveter large enough to do boiler work from a bail attached through a system of sheaves and tackles to a counterweight of one-fourth the weight of the riveter and having four times the travel. Then all that was necessary to do was to have a small chain block on the trestle to overcome friction of the sheaves and tackle. In that way we could raise this machine with a chain block for any diameter of boiler.

We have in very successful operation a machine with a 10-feet 6-inch gap, weighing about 25,000 pounds. We are now installing several other machines of this character, and it seems to be quite a feasible plan. It has several advantages over the ordinary Tower system. It takes up very much less room and the initial cost of installing the plant is very much smaller. This system requires no hoisting of the boiler, as it is simply rolled on the floor or on the rollers. Thus the power plant of the machine is limited to that necessary to actuate the toggle.

COSMOPOLITAN ENTERPRISE

Five Frenchmen, all residents of Paris, have incorporated a company in New Jersey to work copper mines in Spain and filed articles of incorporation with the county clerk at Jersey City the other day. It is known as the Lealtad Copper Mine Company and is capitalized at $500,000. The incorporators are J. Duggue de la Faucon Nerie, Dr. René le Fournier, Dr. Jacques Hulat, Amand Galbrun, Felix Broose and Benjamin Treacy, of No. 15 Exchange place, Jersey City, who is the resident incorporator.

Seven miners were suffocated by "white damp," or carbon monoxide, on July 11 in an abandoned working of the Lehigh and Wilkes-barre Coal Company, at Honeybrook, Pa. Two of the men had been sent in to measure the water; then two more went in to assist them; later, in the belief that the force was inadequate, three more were ordered in. When the men did not return a rescuing party went in and discovered the presence of the "white damp"; the rescuers themselves were overcome after recovering but one body. "White damp" is the most treacherous and difficult to detect of all mine gases; it cannot be detected with a safety lamp, which burns brightly in it. It is a narcotic poison of rapid effect; 1½ per cent. of it in atmospheric air will cause death. It results from mine fires and imperfect combustion and is found where heavy blasts have been set off and subsequent ventilation has been inadequate. A ventilating fan to clear the workings was installed after the accident.—*Engineering News.*

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

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CONTENTS.

INFORMATION PRECEDING IMPROVEMENT

The article in the present issue which deals with "A Month's Output of Air Compressors" by a single manufacturing company, brings out several points of interest. To us at the present moment the thing most prominent is the variety and diversity of the industries in which compressed air now finds employment. The list given in the article is, after all, only a hint of the range of employment, for the sales of each month would continually extend the field. We may certainly say that notwithstanding the diversity of employments indicated the use of compressed air would be much more extensive than it is if all were familiar with it, as comparatively few still really are.

The air compressor is no longer dependent, as at the beginning, upon the rock drill as its employer. It finds other work all the while for itself, and it makes its way by first making acquaintances and then friends. It is now the most familiar experience that wherever a compressor is newly installed and compressed air is given employment for the first time in any establishment, say for operating a few hoists or for a pneumatic tool or any other special apparatus, the air invariably soon finds other work to do and the compressor originally installed is never big enough.

Railroad shops have done more than most others toward familiarizing workers generally with the handiness and the ever-readiness of compressed air; and this has come, as we all know, from the fact that in the beginning it has been so easy to set up an airbrake pump to supply, say, one or two air hoists, these being the things usually so first employed in railroad shops. Soon compressed air is connected to do some other operation, a second pump is called for and then a third, until sometimes a dozen airbrake pumps have been set up before the railroad men have learned, or at least have realized, the extravagance of them as power wasters rather than compressed air producers.

The users of rock drills and of other air operated apparatus, and especially coal mines, have generally been content if only sufficient air has been supplied for their present purposes, with little inquiry as to the efficiency of the machines, and it is only after years of extravagant and easily avoidable waste that

they are beginning to realize the savings which may be effected, the realization only coming with fuller and more correct information as to what may be done, and especially as to what is actually being done by those who are most successful and who are realizing the largest profits. If the information which is ultimately proving effective had been earlier and more widely distributed the results of it also would have been more satisfactory.

Compressed air is getting new employments continually and the use of it is increasing more rapidly than ever before. The numbers are vastly increasing of those who for their own good need to know more than they do of the winning details of compressed air practice. Information in this line it is the life business of this publication to supply. It proposes to do its work thoroughly and faithfully, and it is entitled to the help and encouragement of those who have it in their power to make the way for it.

THE DEVELOPMENT OF NEW NAMES

We don't always realize our responsibilities at the critical moments. The making or the placing of names for new things is a case in point. The Linotype people, we understand, constantly regret that the name of their modern mechanical wonder is not pronounced as they intended, and therefore does not carry to the public the essential idea intended to be conveyed. The work of the machine, as we all know, is to cast a line of type, and the name was meant to be line of type, line-o'-type, lineotype. Unfortunately, perhaps some "simplified" speller had a hand in it, the letter "e" was left out of the word and it is pronounced, with dictionary authority, too, as if it was spelled linnotype, with the first syllable short, and the basic idea consequently is lost.

Another case, in which, however, the conditions are as different as can be, is that of the Electric-Air rock drill. Here, also, there has been the intent to produce a name which would correctly characterize the thing, and here, also, the result has been anything but a success. The name certainly carries its suggestions. There are electric drills and there are air drills. The friends and promoters of the Electric-Air drill might from the name claim for it all the good qualities of both, and the enemies and competitors of it might say that it embodies all the objectionable features of each, but either way of taking advantage of the name would, upon investigation, fail, for the name is a double misnomer. It might quite truthfully be said that the Electric-Air drill is apparently so called because it is neither an electric drill nor an air drill. It certainly is not an electric drill, as the electric current does not come in contact with the drill in any way nor within several feet of it, and while the actual electric drills which have been tried have made such a poor show in the world, it is a heavy handicap on a new drill to have the same family name. So too, the drill is not an air drill, as such drills have heretofore been known, with the piston alternately driven in one direction and then in the other by direct air pressure, and the air for each stroke at once exhausted into the atmosphere. The action of the air in this drill is so different that the fullest knowledge of the regular air drill is, to the extent of its completeness, a disqualifier for a correct understanding of this.

Then, again, the little portable electrically driven air compressor which is a part of the apparatus of each Electric-Air drill is not an air compressor, and its name is another misnomer. That is, it does not do what an air compressor is understood to do. It does not take in successive charges of air from the atmosphere, compress the air and pass it along and then take in more, and so on. It plays the same air back and forth, and is, in fact, a pulsator rather than a compressor, and not being a compressor, neither the good nor the bad qualities of a compressor are properly assumable for it in consequence of its false name.

This apparatus is so novel and revolutionary, and promises to make for itself such a place in the industries of the time, that it deserves a new and distinct name all its own, quite as much so as did the Kodak. It is no wonder that the dictionary grows and that after all it is always behind. New things spring into being which none of the old names fit, and so there must be new ones continually. Things which do things, things which have to be talked about, develope handy names of their own, and we may expect one before long for the Electric-Air drill. The little motor boats on the St. Lawrence are locally known only as "put-puts."—*Cassier's Magazine.*

THE ELECTRIC-AIR DRILL AT THE JAMESTOWN EXPOSITION

The half-tone on this page appears here in its own right, being well worth looking at for its own sake, and we trust our readers will appreciate it as we do. It shows the Electric Air Drill at the Jamestown Exposition, in the exhibit of the General Electric Company. It beautifully illustrates the coöperation of electricity and air in the world's winning work. While surrendering none of its attributes as a pneumatic apparatus, there was still nothing more entitled to a place in an electric exhibit than this, for electricity is its only source of life and power. It is one of the successful and satisfactory inventions, such, for instance, as the switch and signal devices, which enable the electric current to do its most effective work only by the aid of the air. It encourages the hope that compressed air may find many other opportunities to make practicable and profitable the employment of electricity in the responsible operations of our various industries.

ELECTRIC-AIR DRILL AT THE JAMESTOWN EXPOSITION.

COMPRESSED AIR IN RAILWAY SHOPS

The presentation at the Central Railway Club of the interesting paper by Mr. W. P. Pressinger, which we printed in abstract in the preceding issue, was followed by an interesting and suggestive discussion, portions of which also are here reproduced:

TIGHT PIPES.

Mr. J. O. Gould—We have a number of miles of our air piping under ground. In laying the same out, we divided it up in sections by placing valves so we could test out with pressure gages. We pump the line up to pressure, then close the several valves and shut down the compressors with the gages on at different points. If there is no perceptible drop we are satisfied that the lines, valves, etc., are tight.

OIL FOR PNEUMATIC TOOLS.

Mr. C. H. Potts—I notice the author says in his paper that he uses oil for submerging his tools. I would like to ask what kind of oil he has found the best? Also, the best lubricant for lubricating pneumatic tools after they have been taken from the oil bath?

Mr. Aldcorn—We generally use kerosene for the baths in which the tools are immersed and blow them out in the morning. Every company has its own oil. Different kinds are made. We use an oil made by the Galena Company called airoline. It is a light oil and will not congeal in the tools—that is, for the hammers. We also use for the drills a grease made by the same company, which is not a fluid oil.

INSUFFICIENT COMPRESSOR PLANT.

Vice-President McKenna—One part of this paper refers to the installation of the air plant. I think any of us who have visited any plant of any size have been impressed with the fact that it resembles to a great degree a sort of a crazy-quilt affair. I mean that apparently no complete design of the plant has been made in the first place; it has been a case of patchwork. The amount of air to be consumed at any shop or any plant for a certain period of time is the first matter to be taken into consideration. The trouble is that we are very apt to figure that it will take about so much air. Then we figure on a compressor about one-half of the size, feeling that the work will be intermittent in its character. The result is that we gradually add to the use of our air plant, and in a short time we find ourselves seriously handicapped by the lack of it. Carefully prepared plans should be made, keeping in view the actual requirements at that time Then, owing to the increased consumption which will certainly develop later on, and by the installation of large compressors and large pipes, I think the results will be much more satisfactory than are obtained at the present time in many plants. In laying out pipe lines, either in shops or in yards for testing, means should be provided for return movement. Plants are often seriously handicapped by depending on the one main line. In the event of accident no means are provided for carrying on the use of the air. The piping should be laid off in sections, with suitable valves, which not only gives the benefit of the air being available in every direction, but also, as has been referred to here, testing up in certain sections becomes possible.

CARE OF PNEUMATIC TOOLS.

Mr. Hogan—The care of tools is something that is very interesting to watch. Sometime ago at the Depew shops we were not getting the service we thought we should from the air tools we were using. Our general foreman looked into the matter and found that they were not given the care and attention they should have, particularly in the way of lubrication, they were wearing out very fast, and they were thrown about promiscuously as though they were not valuable. But after we took the matter in hand and organized a system of caring for them it increased the efficiency of the tools and the output of the shop.

Mr. McKenna has touched on a very important point in connection with the use of air, *i. e.*, proper installation, piping, etc. We know, too, from experience, that good results can be obtained from installing return pipes or putting in valves that will permit of control of different sections throughout a large plant, particularly in case of accident.

Compressed air is indispensable so far as large shops are concerned, but it is costly if not properly looked after. No matter how large a compressor we install, if we permit leaks to develop and give them no attention, it costs considerable money to compress air. The proper methods for producing air, and utilizing it after it is produced, have been pretty well developed. It is now up to us to give them proper care.

Mr. Wanamaker—I would like to ask Mr.

Aldcorn how often air tools should be oiled while in use?

Mr. Aldcorn—That is another thing that depends on the air you are using, whether your air is moist or dry. If you are using air that has no moisture, you might have to oil—well, take a drill; if you are using grease in it or solidified oil, about twice a day. A hammer ought to be oiled oftener, because you use very light oil in it—probably three or four times a day. Our experience has been that if you use an oiler or atomizer, so that you can feed the oil in steadily, you will get better service out of your hammers and they will last much longer. We mention that in the paper, the using of an oil cup to atomize the oil into the hammer. Of course you cannot do that with a drill because it takes so much more.

Mr. E. A. Miller—I do not think too much can be said in regard to the merits of compressed air in our shops. As Mr. McKenna has said, our air plants have, like Topsy, "just growed," without much system or regularity, and there are very few shops to-day that are using their air plants to the best advantage, especially from this cause. The proper way to find the leaks is to have the plant provided with stopcocks so that it can be divided off into sections, and frequently, in the evening, when the shops are closed, or at such time as it may be found best, to have the lines pumped up to full pressure, the pumps stopped and let the gage show to what extent there are leaks. Then let the inspector close the shut-off cocks of different sections of the pipe, apply a gage to each section, until the part of the pipe where the leaks have developed is shown. That saves an inspection of the entire plant because it locates the leak in the section of the plant without going over the whole plant. By doing this the pipe lines can be kept up with the minimum amount of labor. Another thing that is very essential at the present time is the educating of men to the necessary care of closing valves and cocks and connections, to avoid the waste of air when they are not using it. Men generally consider that air doesn't cost anything. It doesn't as we breathe it, but it does when it takes coal to compress it. The importance of educating men to the proper handling of the air is one of the problems that we have before us at the present time.

The problem of getting plants systematically and properly installed is another important matter that we have before us. It is so easy for the foreman of some department who wants air some place to get pipe, possibly from the scrap pile, put in his connection and install his air plant. In a very short time it is wasting more air than the plant is worth. Then, too, we must understand that many men are being benefited by the air who have never given any thought to the economical side of anything connected with machinery. For instance the laborer is benefited by the use of air as well as the high-priced mechanic. I remember when I was working at the vise that about the hardest part of the labor I found in fitting driving boxes was placing them on and off the axle to try them. Now the man touches the valve and the air lifts the driving box and places it on the axle in much less time than he could lift it by hand. The men have had no knowledge of the economy that should be practiced in watching for leaks and economically using the air. Air is being applied in many ways to lighten labor and quicken work, from the highest priced mechanic down to the cheapest labor that we have. The important thing is to use the air sensibly; to head off the fellows with all sorts of fads and fancies who could do the work quicker and better without the air. To use the air economically he should have the plant provided with necessary valves and proper couplings; divide it up into sections, that it may be inspected quickly to determine whether there is a leak, and if there is a leak to know in what section it occurs. These are the important points.

Then take care of the tools. I am glad that emphasis has been placed by so many of the speakers to-day upon the care of pneumatic tools. The first hammer that we used cost $110. You can get such a hammer now for $60 or $80. But they were new at that time, and when we made the requisition I said to the storekeeper: "Now, when that hammer comes let me know; I want to see it." A few weeks later he came into my office carrying the hammer in one hand and the bill in the other. He said: "Here is one of the fixtures for that hammer, but the hammer hasn't shown up yet." "Well," I said, "that is the hammer." He exclaimed, "My goodness! you say that little thing cost this amount of money?" holding up the bill for $110. "Yes," I said. "Well," said he, "I don't understand it." "No," I said, "I suppose not." Now there are many people just like that storekeeper. They don't understand the pneumatic tool. They don't understand

that in that simple little tool there is $110 or $140 worth of machinery. They throw it around, taking no more care of it than they would of a monkey wrench or a common chipping hammer that they use every day. It is incumbent upon those in charge of plants to educate men to the importance of taking care of these tools just as they would of any high-class machinery or of our plants, and also to teach them to use the air sensibly in all varied work.

RECEIVER CAPACITY.

Mr. J. P. Wright—Speaking of the main air line I would call attention to the fact that it should have proper reservoir capacity. The air pipes should be large so that you can always depend upon them for a reservoir when you have an unusual draft upon your power. Besides that, you can get a better joint with a big pipe. These air systems are usually installed by contract. The contractor cannot cut down the size of the compressor specified, but he can and he does cut down on the size of the pipe. This is where the fault comes in in the installation, and where most of the trouble occurs later on.

EXPERIENCE WOULD DOUBLE CAPACITY.

Mr. Aldcorn—I would just like to say a word about installation. If people putting in air plants would call in people of experience it would save them much trouble. Our practice has been, if a man ask our opinion, to tell him the experience of others; that is, of putting in too small a plant. We advise him to put in a compressor of probably twice the capacity he seems to need at first. If he has any sort of plant we will guarantee that within a year he will have another one just the same size. Where one very large compressor is required we advise that it be installed in two units, which I think is a great deal better. You can't put in too large a pipe line, but you can put it in too small. You cannot give your pipe line too much care, as to leaks, etc.

I have in mind one plant that has 16,000 feet of free air a minute going through the mains every day in the week. They use an 18-inch main line through the yard, and their branches are 6-inch. These lines are tested once a day. They have one man who does the testing and nothing else. He does it at the noon hour, the main line first, shutting off all others, and of course pumping up and having full pressure on the receivers. They have receivers with pressure gages all over the yard. After testing the main line he tests each of the outlets, one after the other. If he finds a leak it is repaired at once. The president of that company told me that man pays his salary ten times over. You know it takes about one horsepower to compress five cubic feet of free air per minute to 100 pounds; also that a little hole, a sixteenth of an inch in diameter, will leak out a horsepower.

LOSSES IN POWER TRANSMISSION AND TRANSFORMATION

The following appeared a short time ago in the form of a letter to *The Engineer*, London. It is interesting and readable, and tells its own story all through. The writer says:

"Sir.—I remember seeing in my early days a manganese mill driven by a water wheel. The water for working the wheel was pumped from the tail-race of the wheel by means of a Newcomen steam engine into a pond, from which the wheel took its supply. The combination formed a means of transmitting and accumulating power, for it is obvious that the engine might be kept pumping while the mill was idle. I see that such a system is proposed for working the machinery of the mines in South Africa. Turbines at the Victoria Falls—700 miles away—are to pump water into a pond on the Rand, from which the Rand mines are to take their power by means of other turbines and motors.

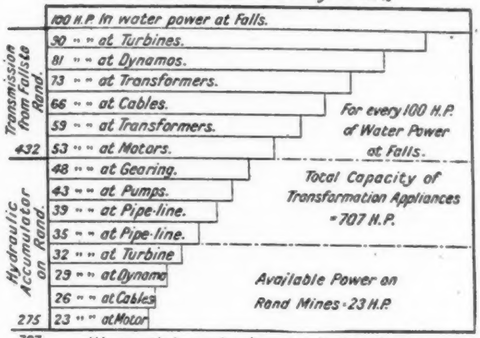
"In my youthful wisdom I looked on the Newcomen engine and water wheel as a rather clumsy and expensive scheme, but in my mature age I ask myself whether, in our anxiety to do everything through the medium of electricity, we do not often propose, and sometimes carry out, more imperfect engineering work.

"In driving the manganese mill the losses due to the indirect method of driving were in the pumps and water wheel; that is to say, there were two tranformations in the transmission. Each transformation, of course, causing a loss of energy. I find in the Victoria Falls scheme that there are no less than fourteen transformations, each representing a loss of energy. The losses are not the same percentage for each transformation, and I shall not attempt to estimate what each individual loss would be. For the sake of illustrating my argument, I will assume a uniform efficiency of

90 per cent.; not a low efficiency for things generally. On this assumption every 100 horsepower taken from the falls will dwindle down to 23 horsepower at the consumer's premises on the Rand mines, and the total power represented by the various appliances employed to produce that result would be 700 horsepower. This is shown clearly on the accompanying diagram. It is true some of the

Power Diagram.

Assumed uniform efficiency at 90%



Illustrating mechanism required and power lost in Transmission and Transformation.

power would be distributed at the sixth stage—see diagram—with a corresponding advantage; but the value of the scheme as a commercial undertaking must be based on the total cost of the whole, plus the working expenses. Leaving out of consideration the working expenses, which would be necessarily very considerable, the great cost of the undertaking, compared with the net result, would in itself make the game not worth the candle. Long distance electric transmission is very interesting, but it is only of practical value when it returns to the investor a fair interest on the money invested.

"My object in writing this letter is to point out that the adoption of up-to-date notions, like change in fashions, often leads to expenditure incommensurate with the advantage derived, and I only use the Victoria Falls scheme as an illustration to show how much energy and hard cash one can fritter away by transformations. I do not think that the commercial value of the scheme has had the practical consideration and investigation which should be given to an undertaking for which the public are invited to provide so much money.

"HENRY DAVEY."

A cube of air 31 feet on each side weighs over a ton.

THE USE OF PNEUMATIC TOOLS IN WORKSHOPS*

By CHARLES PALMER WHITCOMBE, M.Inst.C.E

It may perhaps be difficult for those now concerned in the every-day use of pneumatic tools to realize that only about ten years have elapsed since portable pneumatic tools of a suitable design for general use in workshops became readily available in this country, the tools specially referred to being the hammer—for chipping, caulking, and riveting, and the drill—for boring, tapping, reaming, and like purposes. Previously, high-pressure air had been occasionally employed in workshops, but the machines utilized were of a class distinctly different from the hand tools which have in recent years won their way to the front.

INSTALLING A COMPRESSED AIR PLANT.

The main points demanding attention when installing a compressed air plant are:

1. Capacity of air compressor.
2. Method of driving and general design of air compressor.
3. Arrangement and capacity of air mains, receivers, and service pipes.

In fixing the capacity of the compressor a very ample margin should always be allowed, it being quite impossible to accurately foresee all future requirements. The type of machine is frequently determined by the space available, and the method of driving by existing conditions. Steam-driven machines are, where practicable, generally installed in preference to belt-driven. Driving by direct coupling to an electric motor is often adopted, but the interposition of a rope-driven countershaft affords a very effective alternative arrangement of electric drive. For air pressures of 80 pounds per square inch and upwards the use of compound air cylinders and an intercooler will effect an appreciable saving, and where a steam pressure of 150 pounds or more is procurable, compound steam cylinders are advisable.

Air mains should be of liberal diameter, thus affording storage capacity and tending to avoid loss of pressure by friction. Separate receivers should be located near the principal points of consumption; water traps and drip cocks should be provided in convenient positions; all joints and connections should be insured against leakage, occasional tests being desirable. Theoretically, the reheating of com-

*Paper read at the Engineering Conference of the Institution of Civil Engineers, June 20, 1907.

pressed air, when the distance traversed is considerable, should be productive of economy; but very little attention seems to have been directed to this matter so far as workshop plants are concerned, the reason being, probably, that a reheater to be fully effective must be placed close to the point at which the air is actually used. This requirement would in most cases prove prohibitive, but not, perhaps, where compressed air is used for operating power hammers, and a test of the results of reheating under such circumstances would certainly prove interesting.

RECENT IMPROVEMENTS IN PNEUMATIC TOOLS.

It may be assumed that the distinctive characteristics of the designs of pneumatic hammers and drills which have established their position are fairly well known; no radical changes appear to have been effected during the past few years, but the efforts of designers and manufacturers have been directed, with a considerable measure of success, to improving the construction, economizing the air consumption, and facilitating the operating.

MAINTENANCE OF TOOLS.

Maintenance in the highest state of efficiency is essential to the satisfactory operation of pneumatic tools, and the prompt replacement of a defective part frequently exercises a vital influence on the out-turn capacity of the tool concerned. Such replacement is facilitated by the interchangeability of parts, due to the system of manufacture adopted in the production of these tools. It is usual when large numbers of tools are in constant use to arrange for their periodical examination and test by selected workmen, and it will be at once recognized that the general adoption of this practice might be expected to produce very beneficial results.

COMPARATIVE SPEED CAPABILITIES.

From actual results the following comparisons of speeds of out-turn as compared with hand work have been compiled; it is not claimed that these speeds are applicable to all classes of work, but that they can be generally attained and sometimes even exceeded:

Description of work.	Speeds By hand.	Speeds By pneumatic tool.
Heavy chipping	1	2 to 4
Caulking	1	3 to 4
Drilling	1	3 to 4
Rimering	1	4 to 6
Riveting	1 (3 men)	1½ to 2½ (2 men)

ECONOMICAL RESULTS.

The economical results achieved, so far as piece-work rates alone are concerned, are not nearly proportionate to the higher of the speeds enumerated above, but the reduced rates which have formed the subject of agreement between employers and employed, enable the latter to earn higher wages in a given time, and the increased rapidity of out-turn constitutes an important item for the employers' consideration when comparing results with hand work. The following figures show, approximately, the reductions in piece-work rates effected by the use of pneumatic tools in the United Kingdom:

Description of work.	Percentage off hand-labor rates.
Chipping	35 to 50
Caulking	35 to 55
Drilling	40 to 60
Rimering	50 to 75
Riveting	30 to 50

Figures recently prepared by a leading firm for their own information showed that a weekly saving of more than £2 was being effected in wages for every pound sterling of running cost of the pneumatic plant, the latter including interest on capital outlay, depreciation, power charges, maintenance and repairs. The number of tools owned by the firm concerned exceeds 80, and their compressing plant has a capacity of 1,500 cubic feet of free air per minute.

Reductions in piece-work rates in Germany are reported to vary as follows:

Description of work.	Percentage off hand-labor rates.
Chipping and caulking	35 to 65
Drilling	50 to 80
Riveting	35 to 60

GENERAL REMARKS.

The advantages derivable from the use of modern portable pneumatic tools for special purposes are now, it is considered, admitted with practical unanimity; some of those who were among the most determined opponents of such tools are to-day found in the ranks of their warmest advocates. The demand for these tools has steadily increased year by year, though not so rapidly in the United Kingdom as in the United States and in Germany; this difference has been due mainly to the opposition experienced here to the use of portable riveting tools, an opposition which it is understood has recently been to a large extent overcome, and in that case a continuation of the growth of development in this country may be reasonably predicted.

TRADE PUBLICATIONS.

Sullivan Mining Hoists.—Sullivan Machinery Company, Chicago.—24 pages, 6x9 inches, 26 illustrations. Illustrates and briefly describes heavy hoisting plants built by this company for deep mine service.

A Quarter of a Century Building High Grade Steam Engines and Nothing Else. Ball Engine Co., Erie, Pa.; 18 pages, 6½x6 inches, folded to 6x3¼ inches; 14 half-tones. Describes the various styles of engines built by the company.

Bantam Anti-Friction Booster, No. 1, Bantam, Conn.—4 pages, 13x21 inches, yellow in color. Inside pages give information about Bantam ball bearings. Outside astonishing and indescribable, and what might be expected from the man responsible for it. The outside will be read whether the inside is or not.

The Temple Ingersoll Electric Air Rock Drill.—Form 20, Ingersoll-Rand Co., New York; 60 pages, 6x9 inch; profusely illustrated. The drill is fully described and all its details are shown. The half-tones show the drill in operation under various and widely different conditions, and records of performance are given which show most remarkable results, especially in power cost for operating.

The roof and walls of the New York Fourth Avenue tunnel from 34th to 40th streets, which is traversed by surface cars, were recently being whitewashed by the pneumatic spraying system. A car came along and as a result of something wrong with the apparatus the nozzle was directed right at the car with the whitewash in full flow. The motorman stopped his car and was completely drenched by the stream. Then he started slowly and the fifteen passengers on board all received a similar coating.

The regular monthly meeting of the American Society of Mechanical Engineers on October 8 will be addressed by Prof. John P. Jackson, of the Pennsylvania State College, upon "The Relation of the College Technical Course to the Apprenticeship Course in Industrial Establishments." Prof. Dugald C. Jackson, of the Massachusetts Institute of Technology, and president of the Society for the Promotion of Engineering Education, and Dr. Henry Pritchett, president of the Carnegie Foundation and of the American Society for the Promotion of Industrial Education, will address the meeting. On November 11 Charles R. Pratt will read a paper on the elevators of the new Singer and Metropolitan Life Insurance buildings. The gas-engine and foundry practice will be the leading topics of the annual meeting in December.

The Vredenburg Company, recently organized, whose manager is Mr. Clarence Vredenburg, the only editor and manager of *Engineering World* up to its recent sale, is established at 1332 Monadnock Block, Chicago. It will be engaged in a consulting practice in engineering and general technical advertising.

Tantalum is so hard that the only effect produced by a diamond drill, worked day and night for three days on a sheet of the substance one-twenty-fifth of an inch thick, with a speed of 5,000 revolutions per minute, was a slight dent in the sheet and the wearing out of the diamond.—*Mines and Mining, Denver.*

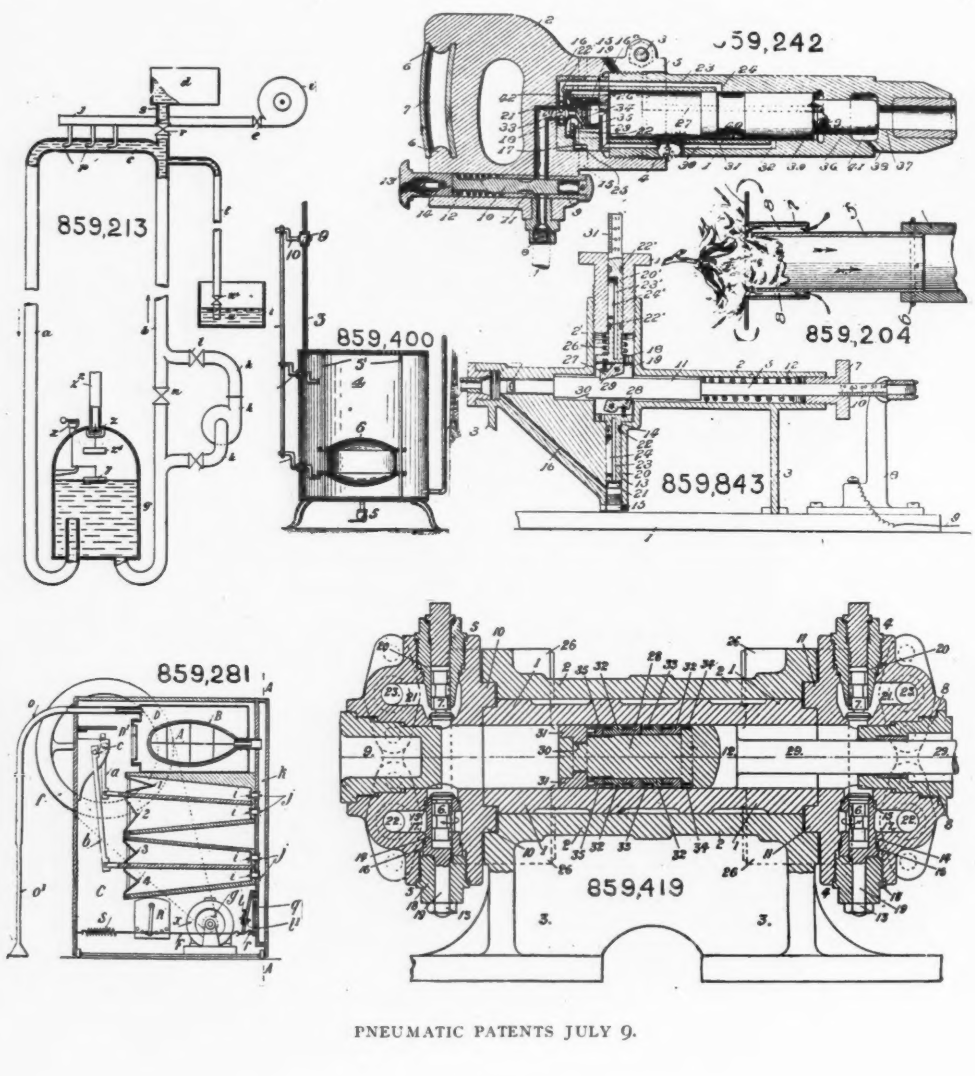
In the erection of the superstructure of the Peterborough hydraulic lock on the Trent Canal, a pneumatic wrench was used for screwing up nuts on bolts up to 1⅝ inches in the large presses and rams. The machine consisted essentially of an oscillating, double-acting air cylinder, the piston of which rotated a box wrench through the medium of a ratchet. The machine weighed about 70 pounds, was handled by two men and did the work of twenty-five in the same time and in a more satisfactory manner.

Bulk for bulk, alcohol will not develop as much power as gasoline but it possesses other decided advantages in the matter of storage. If a can of gasoline, and especially a can only partly filled, be left open near a flame it is quite likely to explode by ignition, which could never occur with alcohol. Water is useless to quench burning gasoline, serving only to spread the flame by floating the liquid, while alcohol mixes with water in all proportions and when so diluted becomes non-inflammable. The safety of alcohol must lead to its adoption for that particular alone in many lines of service, as, for instance, in submarine boats and other hazardous places from which there is no ready escape.

"The Art of Cutting Metals," by Frederick W. Taylor, M. E., Sc. D., which was the presidential address presented at the last annual meeting of The American Society of Mechanical Engineers, has been reprinted and bound in cloth by the Society; price, $3.00. This or any other publication of the Society may be had by addressing the Secretary, 29 West 39th Street, New York. It is not necessary to send orders through members. None of the publications of The American Society of Mechanical Engineers is copyrighted.

CHANNELERS AT PANAMA.

The Isthmian Canal Commission has decided that the walls of the canal, where it passes through rock, shall be channeled. This includes most of the "wet prism" in the Culebra Division, nine miles long, and also the walls of the locks at La Boca and Mira Flores. The wall formed by the channeler is cut exactly to the surveyed line. It is announced by the Sullivan Machinery Company, Chicago, that it has been awarded a contract for 24 Class Y 8 channelers for this work. This machine is similar to, but larger and more powerful than those of Class Y of the same company.



PNEUMATIC PATENTS JULY 9.

LATEST U. S. PATENTS.

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

JULY 9.

859,204. PICKER NOZZLE FOR PNEUMATIC COTTON-PICKING MACHINES. WOODBURY K. DONA, Westbrook, Me.

859,213. APPARATUS FOR COMPRESSING AIR OR OTHER ELASTIC FLUID FOR THE PRODUCTION OF MOTIVE POWER. JOHN GILL, Edinburgh, Scotland.

859,242. PNEUMATIC TOOL. SAMUEL OLDHAM, Philadelphia, Pa.

859,281. MACHINE FOR REMOVING DUST FROM CARPETS BY SUCTION. JULIUS R. BLUM, Paris, France.

859,400. WATER ELEVATOR. EDWARD G. MARTIN and JOHN H. HAKE, Tyler, Texas.

859,419. GAS COMPRESSOR. WALTER H. WEBB, WILLIAM G. BRETTELL and ALEXANDER J. ADAMSON, Liverpool, England.

859,843. CONTROLLER FOR PNEUMATIC COMPRESSORS. LEBBEUS H. ROGERS, New York.

JULY 16.

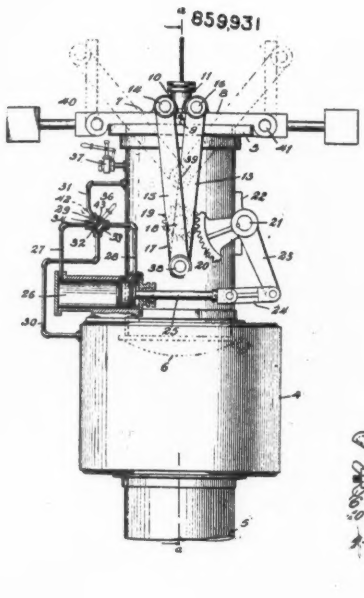
859,914. APPARATUS FOR CLEANING CARPETS. SIEGFRIED BUDER, Halensee, Germany.

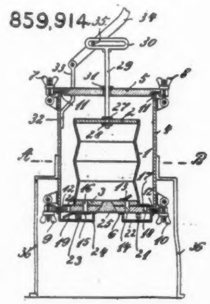
859,915. PNEUMATIC SWEEPER. SIEGFRIED BUDER, Halensee, Germany.

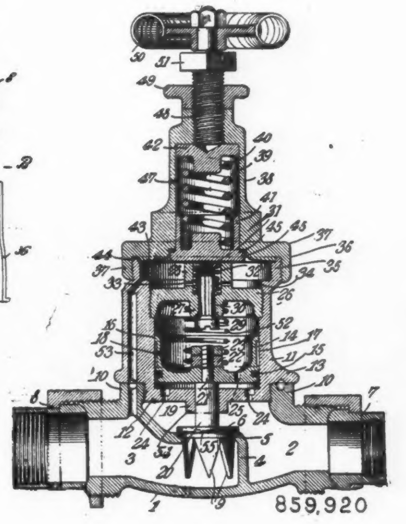
859,920. REDUCING VALVE. HARRY F. CUNNING, Roanoke, Va.

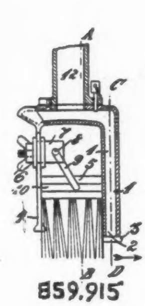
859,931. AIR-LOCK FOR CAISSONS. CHARLES I. EARLL, assignor to John Monks & Sons, New York.

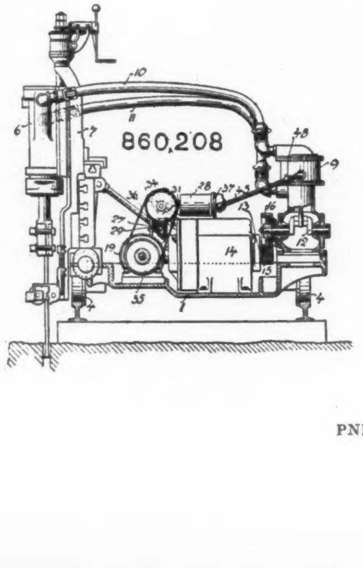
860,208. ELECTRO-PNEUMATIC TRACK CHANNELER. ARTHUR H. GIBSON, Easton, Pa., assignor to Ingersoll-Rand Company, New York.

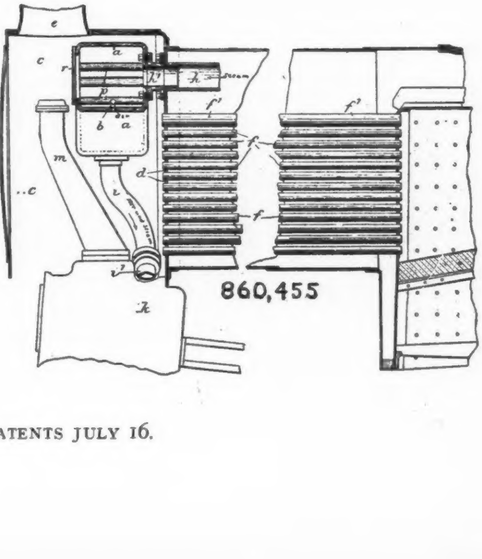












PNEUMATIC PATENTS JULY 16.

860,455. LOCOMOTIVE OR OTHER ENGINE USING A MIXTURE OF AIR AND STEAM AS A MOTOR FLUID. Edward Field, London, England.

860,595. ELASTIC FLUID TURBINE. Charles G. Curtis, New York, assignor to General Electric Company.

JULY 23.

860,622. PNEUMATIC TRUCK. Alexander R. Bannerman, William Summerton, and Donald MacDonald, Winnipeg, Manitoba, Canada.

860,786. SUCTION DEVICE FOR DUST-REMOVING PNEUMATIC MACHINES. Jules R. Blum, Paris, France.

860,826. AIR-COMPRESSOR. William Reavell, Ipswich, England.

860,842. PNEUMATIC FIRE-ALARM. Willard Wadsworth, Plainfield, N. J.

860,851. PNEUMATIC FOR AUTOPNEUMATIC PIANOS. James Carruthers, Newark, N. J.

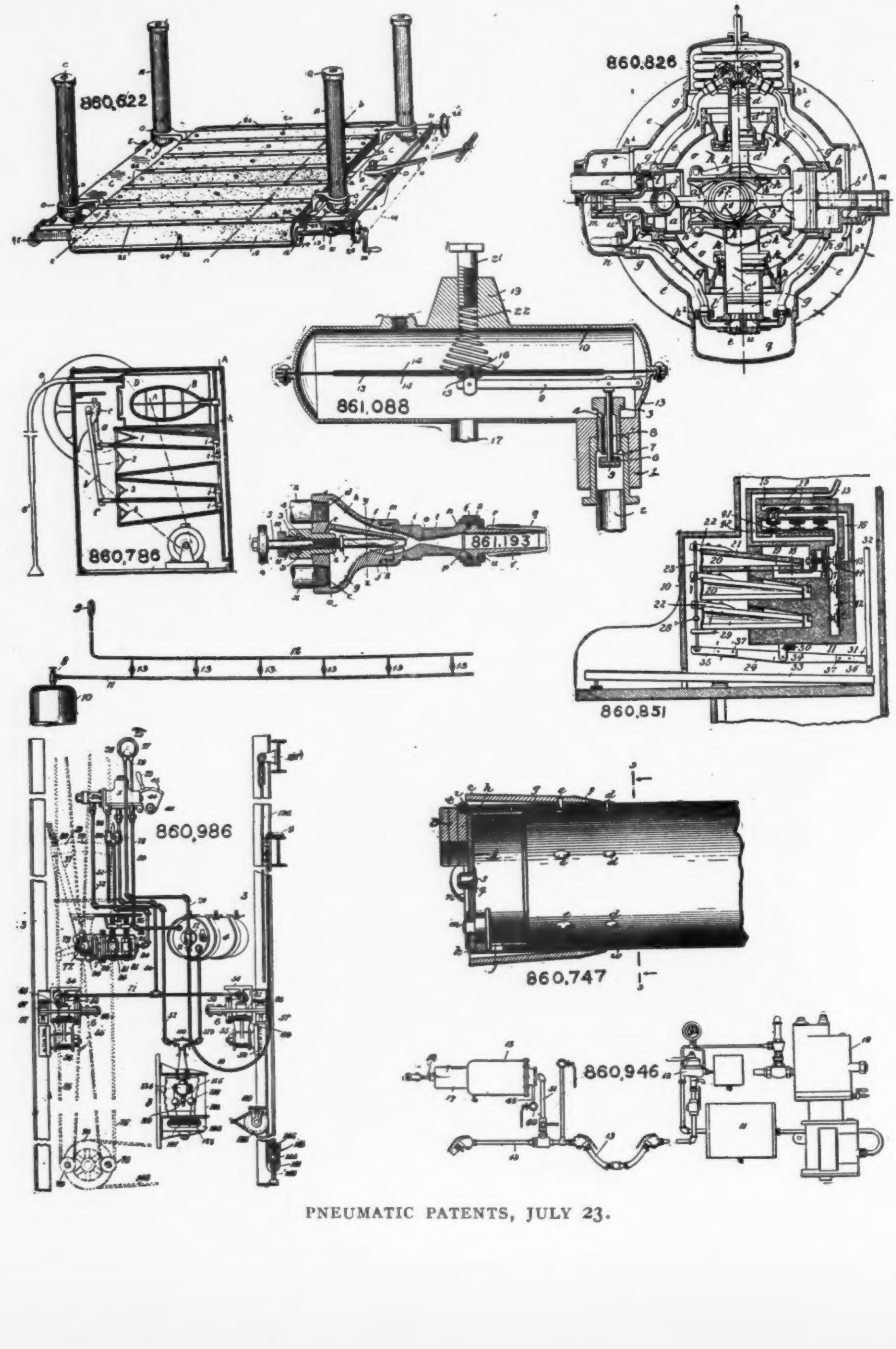
860,949. AIR-BRAKE SYSTEM. Augustus A. St. Clair, Indianapolis, Ind.

860,947. PNEUMATIC-DESPATCH CARRIER. John W. Upp and William O. Wakefield, Schenectady, N. Y.

860,986. ELEVATOR AIR-BRAKE SYSTEM. Alfred H. Meech, Chatham, N. Y.

861,038. AUTOMATIC GAS-REGULATING VALVE. Benjamin M. Lewis, Reno, Nev.

861,193. VACUUM-MACHINE. Phillip H. McCabe and Alphonse J. Lavoie, Toronto, Ontario, Canada.



PNEUMATIC PATENTS, JULY 23.

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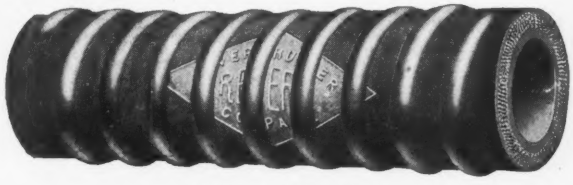

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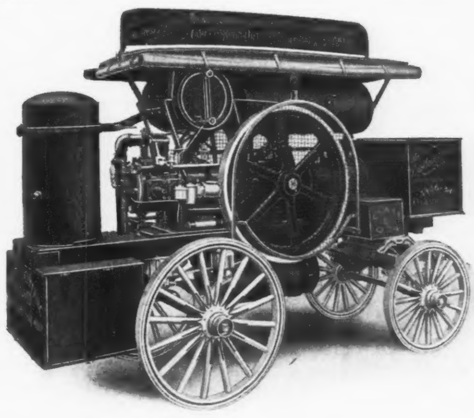

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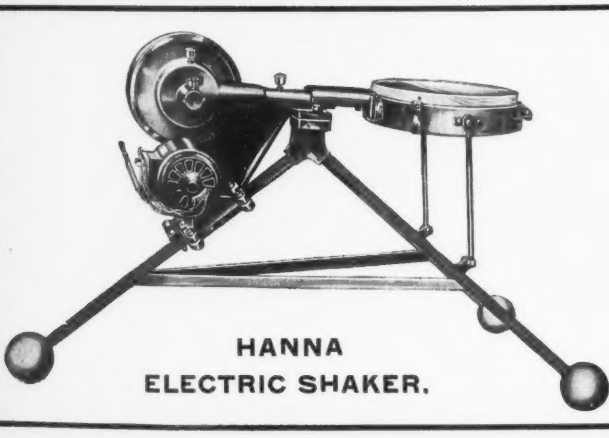

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